Manual Part No. C1947

GENERAC®
POWER SYSTEMS, INC.

1.5 LITER

MITSUBISHI GAS ENGINE

SERVICE MANUAL

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FOREWORD

This manual has been published by GENERAC® POWER SYSTEMS, INC. to aid our dealers' mechanics, company service personnel and general consumers when servicing the products described herein.

It is assumed that these personnel are familiar with the servicing procedures for these products, or like or similar products, manufactured and marketed by GENERAC® POWER SYSTEMS, INC. It is also assumed that they have been trained in the recommended servicing procedures for these products, which includes the use of mechanics hand tools and any special tools that might be required.

Proper service and repair is important to the safe, economical and reliable operation of the products described herein. The troubleshooting, testing, service and repair procedures recommended by GENERAC® POWER SYSTEMS, INC. and described in this manual are effective methods of performing such operations. Some of these operations or procedures may require the use of specialized equipment. Such equipment should be used when and as recommended.

We could not possibly know of and advise the service trade of all conceivable procedures or methods by which a service might be performed, nor of any possible hazards and/or results of each procedure or method. We have not undertaken any such wide evaluation. Therefore, anyone who uses a procedure or method not recommended by the manufacturer must first satisfy himself that neither his safety, nor the product's safety, will be endangered by the service or operating procedure selected.

All information, illustrations and specifications contained in this manual are based on the latest product information available at the time of publication. However, GENERAC® POWER SYSTEMS, INC. reserves the right to change, alter or otherwise improve the product at any time without prior notice.

Some components or assemblies of the product described in this manual may not be considered repairable. Disassembly, repair and reassembly of such components may not be included in this manual.

The engines described herein may be used to power a wide variety of products. Service and repair instructions relating to any such products are not covered in this manual. For information pertaining to use of these engines with other products, refer to any owner's or service manuals pertaining to said products.

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The 1.5 Liter Gas Engine has been engineered for use in Generac Power Systems products. The contents of this manual have been excerpted from the original manufacturer's service and repair manual. The exploded view section at the back of this manual is for reference only.

For a complete listing of all engine parts, refer to Generac P/N PB15000G — "Parts Manual, 1.5 Liter Gas Engine"

Notes

SPECIFICATIONS:

CRANKCASE OIL CAPACITY:	4 U.S. QUARTS (3.79 LITERS)
COOLING SYSTEM CAPACITY:	2 U.S. GALLONS (7.57 LITERS)

RECOMMENDED FLUIDS:

COOLANT:

USE A 50/50 MIXTURE OF LOW SILICATE ETHYLENE GLYCOL BASE ANTI-FREEZE AND SOFT WATER. (IF DESIRED, A HIGH QUALITY RUST INHIBITOR MAY BE ADDED TO THE RECOMMENDED COOLANT MIXTURE.) WHEN ADDING COOLANT, ALWAYS ADD THE RECOMMENDED 50/50 MIXTURE.

ENGINE OIL:

USE A HIGH QUALITY DETERGENT OIL CLASSIFIED *FOR SERVICE SC, SD, SE, OR SF.* DETERGENT OILS KEEP THE ENGINE CLEANER AND REDUCE CARBON DEPOSITS. USE OIL HAVING THE FOLLOWING SAE VISCOSITY RATING BASED ON THE AMBIENT TEMPERATURE RANGE ANTICIPATED BEFORE THE NEXT OIL CHANGE.

TEMPERATURE	RECOMMENDED OIL GRADE
ABOVE 86°F (30°C)	SAE 40
32°F TO 85°F (0° - 29°C)	SAE 30
BELOW 32°F (0°)	SAE 20W
All Seasons	SAE 10W-30

PERIODIC MAINTENANCE SCHEDULE:

A. EVERY THREE MONTHS

1. Check battery state of charge and condition.
2. Inspect and test fuel system.
3. Check transfer switch
4. Inspect exhaust system.
5. Check engine ignition system.
6. Check fan belts.

B. ONCE EVERY SIX MONTHS

1. Test engine safety devices (low oil pressure, low coolant level, high coolant temperature).

C. ONCE ANNUALLY

1. Test engine governor; adjust or repair, if needed.
2. Clean and inspect generator.
3. Flush cooling system.

D. FIRST 100 OPERATING HOURS

1. Change engine oil and filter (After initial change, service engine oil and filter at 150 operating hours or 6 months, whichever comes first.)
2. Retorque cylinder head.
3. Retorque intake and exhaust manifold.

E. EVERY 500 OPERATING HOURS

1. Service air cleaner.
2. Check starter.
3. Check engine DC alternator.

E. EVERY 800 OPERATING HOURS

1. Retorque cylinder head.
2. Retorque intake and exhaust manifold.
3. Check engine compression.
4. Check valve clearance.

1.5 Liter Gas Engine General Information

Description		4G15–CARBURETOR	
Type		In-line OHV, SOHC	
Number of cylinders		4	
Combustion chamber		Semi spherical type	
Total displacement cm^3		1,468	
Cylinder bore mm (inches)		75.5 (2.97 in.)	
Piston stroke mm (inches)		82.0 (3.23 in.)	
Compression ratio		9.0	
Number of valve	Intake	8	
	Exhaust	4	
Valve timing	Intake opening	BTDC 14°	
	Intake closing	ABDC 48°	
	Exhaust opening	BBDC 55°	
	Exhaust closing	ATDC 13°	
Lubrication system		Pressure feed, full-flow filtration	
Oil pump type		Trochoid type	
Cooling system		Water-cooled forced circulation	
Water pump type		Centrifugal impeller type	

Item			Standard	Limit
Rocker arms, rocker shafts, and camshaft				
Camshaft cam height mm		Intake (primary)	38.78	38.28
		Intake (secondary)	38.78	38.28
		Exhaust	39.10	38.60
Camshaft journal diameter mm			45.93–45.94	
Cylinder head and valves				
Flatness of cylinder head gasket surface mm			0.05 or less	
Cylinder head gasket surface grinding limit (including grinding of cylinder block gasket surface) mm			–	0.2
Cylinder head overall height mm			106.9–107.1 (4.209 - 4.217)	
				–
Cylinder head bolt nominal length mm			–	103.2
Valve margin mm		Intake	1.0	0.5
		Exhaust	1.5	1.0
Valve stem diameter mm			6.6	–
				–
Valve stem-to-guide clearance mm		Intake	0.020–0.050	0.10
		Exhaust	0.050–0.085	0.15
Valve face angle			45°–45.5°	–
Valve stem projection mm		Intake	43.70	44.20
		Exhaust	43.30	43.80
Overall valve length mm		Intake	100.75	100.25
		Exhaust	101.05	105.55
Valve spring free height mm		Intake	46.1	45.6
		Exhaust	46.8	46.3

1.5 Liter Gas Engine Specifications

Item			Standard	Limit
Valve spring load/ installed height N/ mm		Intake	226/40.0	–
		Exhaust	284/39.6	–
				–
Valve spring squareness			2°	4°
Valve seat contact width mm			0.9–1.3	–
Valve guide internal diameter mm			6.6	–
				–
Valve guide projection mm			17.0	–
				–
Oil pump and oil pan				
Oil pump tip clearance mm			0.06–0.18	–
Oil pump side clearance mm			0.04–0.10	–
Oil pump body clearance mm			0.10–0.18	0.35
Pistons and connecting rods				
Piston outside diameter mm				–
		4G15	75.5	–
Piston ring side clearance mm		No. 1 ring	0.02–0.06	–
		No. 2 ring	0.02–0.06	–
Piston ring end gap clearance		No. 1 ring	0.20–0.35	0.8
		No. 2 ring	0.35–0.50	0.8
		Oil ring	0.20–0.50	1.0
Piston pin O. D. mm			18.0	–
Piston pin press-in load (at room temperature) N			4,900–14,700	–
Crankshaft pin oil clearance mm			0.02–0.04	0.1
Connecting rod big end side clearance mm			0.10–0.25	0.4
Crankshaft and cylinder block				
Crankshaft end play mm			0.05–0.18	0.25
Crankshaft journal diameter mm			48.0	–
Crankshaft pin diameter mm			42.0	–
Crankshaft journal oil clearance mm			0.02–0.04	0.1
Cylinder block gasket surface flatness mm			0.05 or less	–
Cylinder block gasket surface grinding limit (including grinding of cylinder head gasket surface) mm			–	0.2
Cylinder block overall height mm			256	–
Cylinder block cylindricity mm			0.01	–
Cylinder block I. D. mm				–
		4G15	75.5	–
Piston-to-cylinder clearance mm			0.02–0.04	–

REWORK DIMENSIONS

Item				Standard	Limit
Cylinder head and valves					
Cylinder head oversize valve guide hole diameter mm			0.05 O. S.	12.050–12.068	–
			0.25 O. S.	12.250–12.268	–
			0.50 O. S.	12.500–12.518	–
					–
					–
					–
Oversize valve seat ring hole diameter mm		Intake (primary)	0.3 O. S.	27.300–27.325	–
			0.6 O. S.	27.600–27.625	–
		Intake (secondary)	0.3 O. S.	32.300–32.325	–
			0.6 O. S.	32.600–32.625	–
		Exhaust	0.3 O. S.	35.300–35.325	–
			0.6 O. S.	35.600–35.625	–
					–
					–
					–
					–

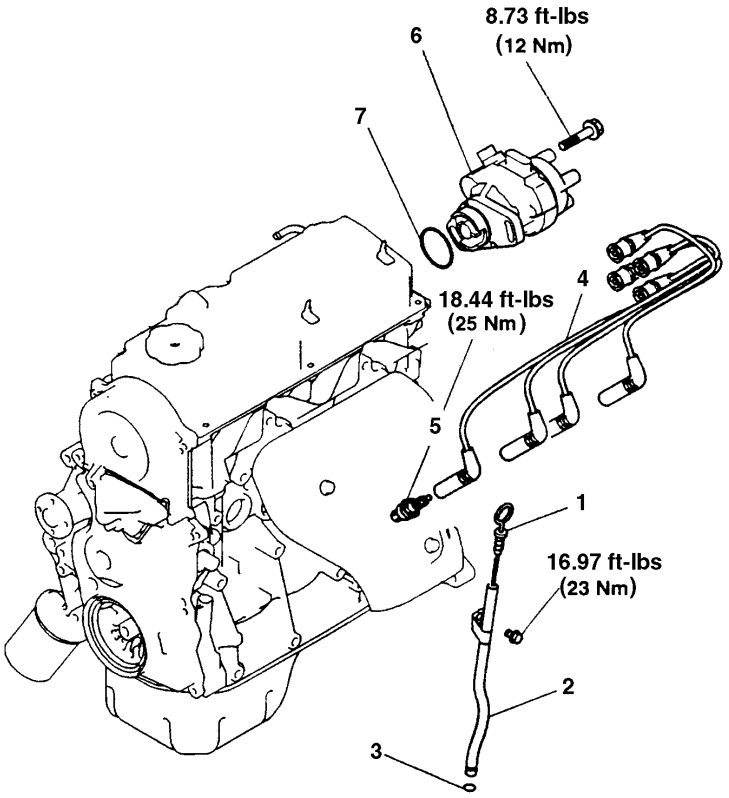
1.5 Liter Gas Engine Torque Specifications

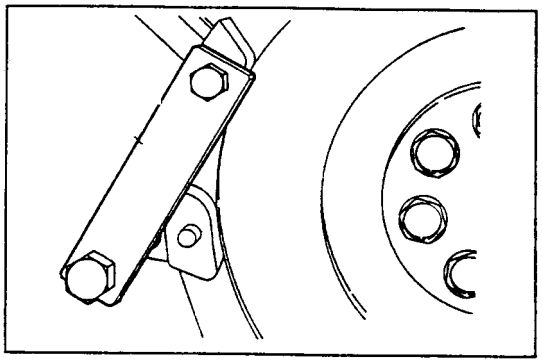
Item	Nm	ft-lbs
Oil level gauge guide	23	16.96
Crankshaft bolt	103	75.97
Spark plug	25	18.44
Distributor	11	8.11
Timing belt		
Timing belt cover	11	8.11
Timing belt tensioner	23	16.96
Engine support bracket (left)	35	25.82
Idler pulley	35	25.82
Camshaft sprocket bolt	88	64.91
Water pump		
Water temperature sensor	29	21.39
Water pump	13	9.59

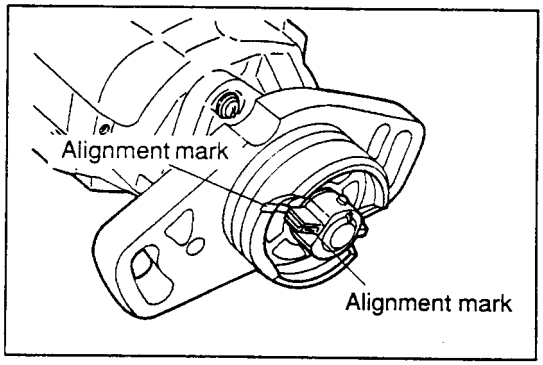
Item	Nm	ft-lbs
Rocker arms, rocker shafts, and camshaft		
Rocker cover	4	2.95
Rocker shaft assembly	31	22.87
Adjusting screw	15	11.06
Bearing cap	24	17.70
	11	8.11
Cylinder head and valves		
Cylinder head bolt Tighten to 36.14 ft-lbs (49 Nm), then completely loosen and retighten as described.	20 + 90° + 90°	14.75 + 90° + 90°
Oil pump and oil pan		
Oil pan	7	5.16
Drain plug	39	28.77
Oil screen	18	13.28
Front case	13	9.59
Relief plug	44	32.45
Oil pump cover	10	7.38
Pistons and connecting rods		
Connecting rod nut	17 + 90° to 100°	12.54 + 90° to 100°
Crankshaft and cylinder block		
Rear oil seal case	11	8.11
Bearing cap bolt	51	37.62

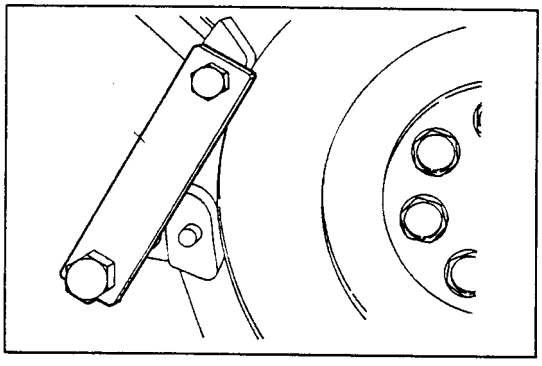
REMOVAL AND INSTALLATION

Removal steps:
1. Oil level gauge
2. Oil level gauge guide
3. O-ring
4. Spark plug cable
5. Spark plug
6. Distributor
7. O-ring









REMOVAL SERVICE POINT

CRANKSHAFT BOLT REMOVAL

(1) Lock the flywheel or drive plate in position using the special tool shown in the illustration, then loosen the crankshaft bolts.

INSTALLATION SERVICE POINTS

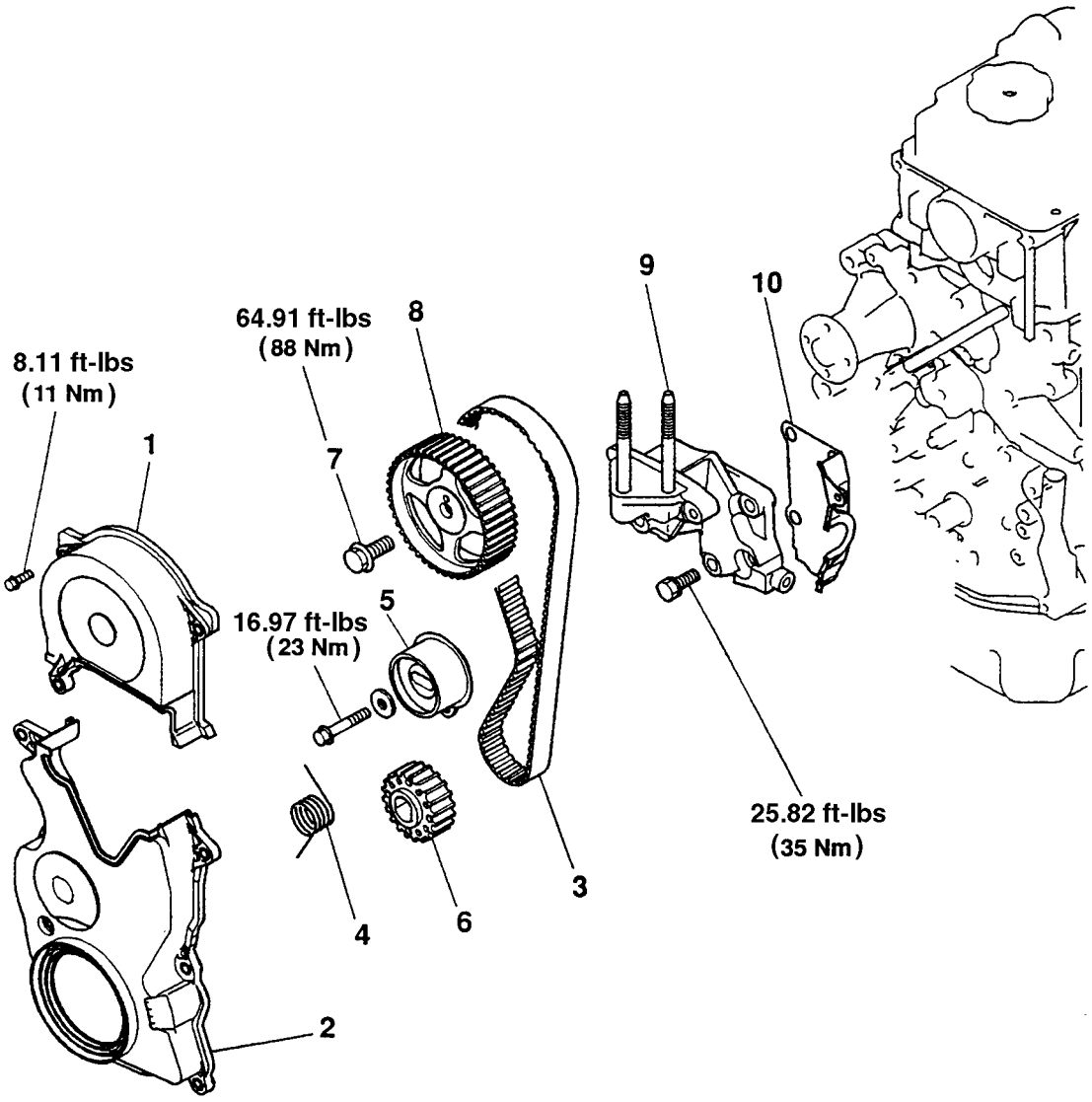
DISTRIBUTOR INSTALLATION

(1) Turn the crankshaft clockwise until cylinder No. 1 is at top dead center on its compression stroke.
(2) Align the alignment marks on the distributor housing and coupling.
(3) Fit the distributor onto the engine, aligning the stud bolts with the slots in the distributor mounting flange.

CRANKSHAFT BOLT INSTALLATION

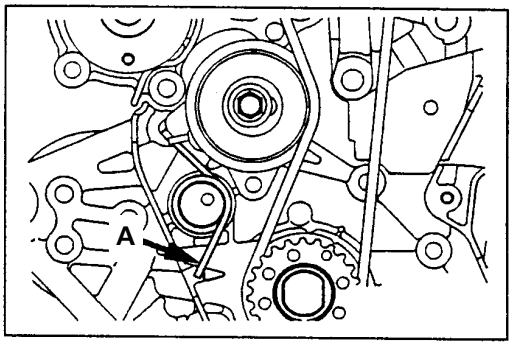
(1) Lock the flywheel or drive plate in position using the special tool shown in the illustration, then tighten the crankshaft bolts.

REMOVAL AND INSTALLATION



Removal steps:

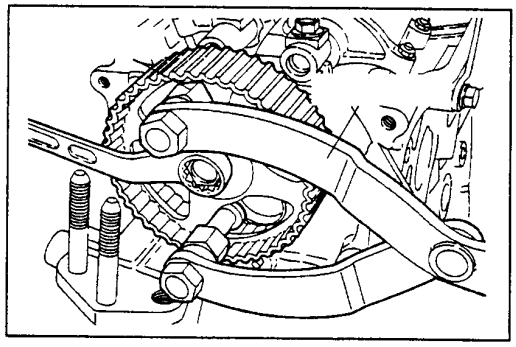
1. Timing belt upper cover
2. Timing belt lower cover
3. Timing belt
4. Tensioner spring
5. Timing belt tensioner
6. Crankshaft pulley
7. Camshaft sprocket bolt
8. Camshaft sprocket
9. Engine support bracket
10. Timing belt rear cover



REMOVAL SERVICE POINTS

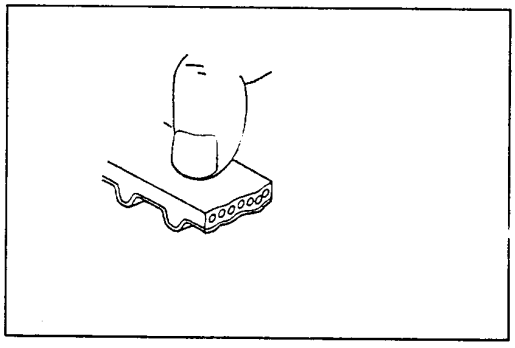
TIMING BELT / TENSIONER SPRING / TIMING BELT TENSIONER REMOVAL

(1) Using pliers, grip the tensioner spring projection (marked "A" in the diagram) and remove it from the oil pump case stopper. Then, remove the tensioner spring.
(2) Remove the timing belt tensioner.
(3) If the timing belt is to be reused, chalk an arrow on the belt to indicate the direction of rotation before removing it. This will ensure the timing belt is fitted correctly when reused.



CAMSHAFT SPROCKET BOLT REMOVAL

(1) Using the special tools shown in the illustration, lock the camshaft sprocket in position.
(2) Loosen the camshaft sprocket bolt.

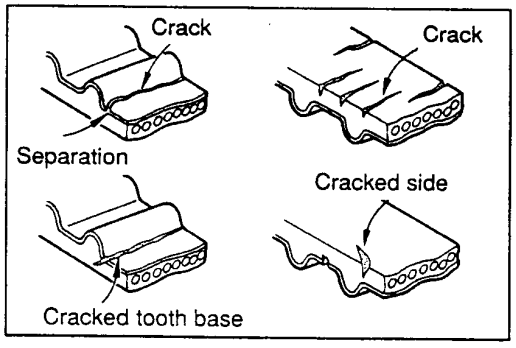


INSPECTION

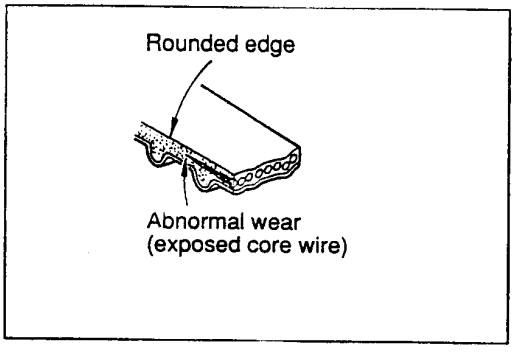
1. TIMING BELT

Check the timing belt closely. Replace the belt with a new one if any of the following defects is evident:

(1) Hardened backing rubber (the backing rubber is glossy, non-elastic, and so hard that scratching with fingernails leaves no mark).



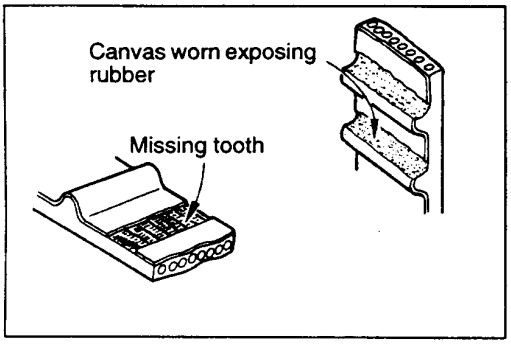
(2) Surface cracks in the backing rubber
(3) Splits in the canvas and/or separation of the canvas and rubber
(4) Cracks at the bases of teeth
(5) Cracks in the side of the belt



(6) Abnormal wear on the belt's sides

NOTE:

The sides of the belt are normal if they are sharp as if cut by a knife.

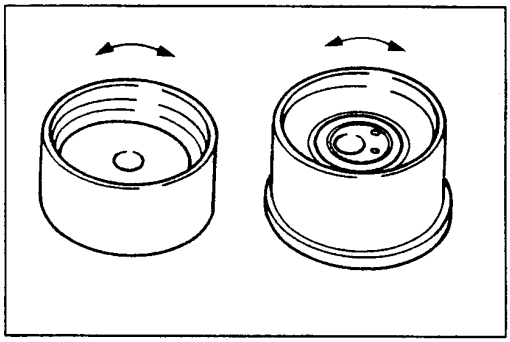


(7) Abnormal wear on teeth

Initial stage:
Canvas worn (fluffy canvas fibers, rubbery texture gone, white discoloration, canvas texture indistinct)

Final stage:
Canvas worn, exposing rubber (tooth width reduced)

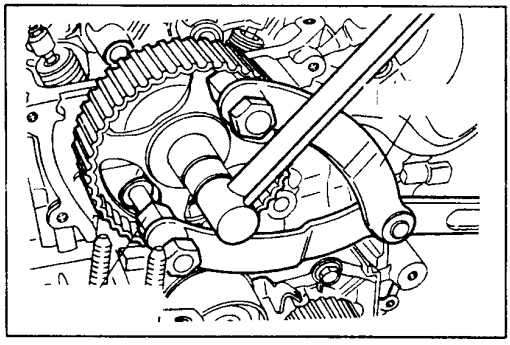
(8) Missing teeth



2. TENSIONER PULLEY AND IDLER PULLEY

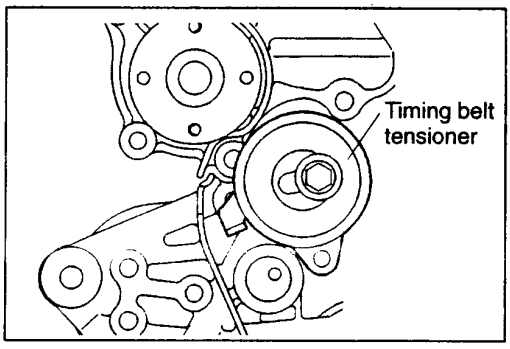
(1) Check that the pulleys turn smoothly without play and are not abnormally noisy. Replace either or both of the pulleys if necessary.

INSTALLATION SERVICE POINTS



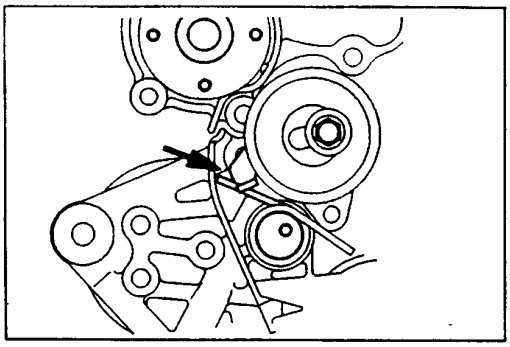
CAMSHAFT SPROCKET BOLT INSTALLATION

(1) Using the special tools shown in the illustration, lock the camshaft sprocket in position.
(2) Tighten the camshaft sprocket bolt to the specified torque.

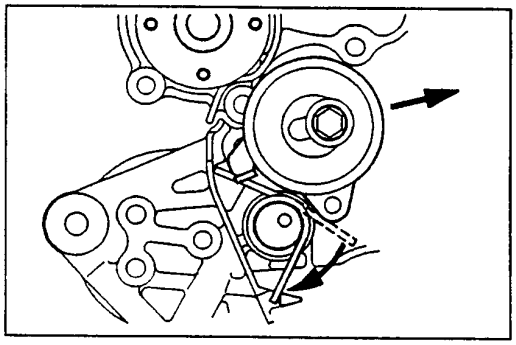


TIMING BELT TENSIONER / TENSIONER SPRING INSTALLATION

(1) Lock the timing belt tensioner in the illustrated position.

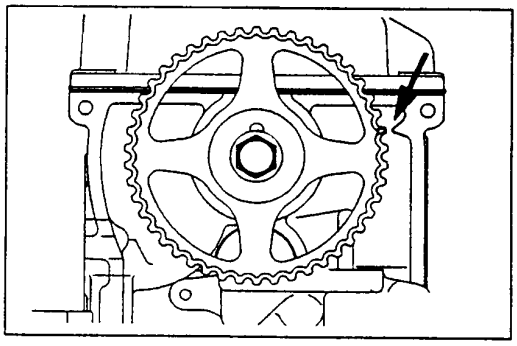


(2) Fit one of the tensioner spring projections over the hooked portion of the timing belt tensioner and fit the tensioner onto the oil pump case.



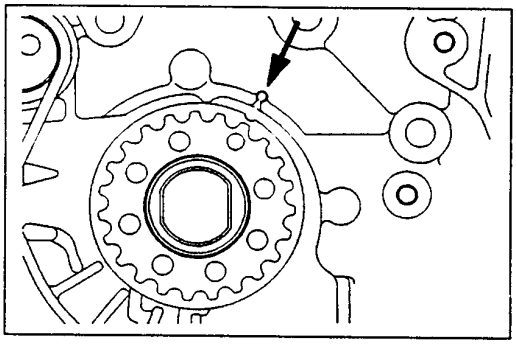
(3) Grip the other tensioner spring projection and fit it onto the oil pump case lug as shown in the illustration.

(4) Move the timing belt tensioner in the direction shown and temporarily tighten the bolt.

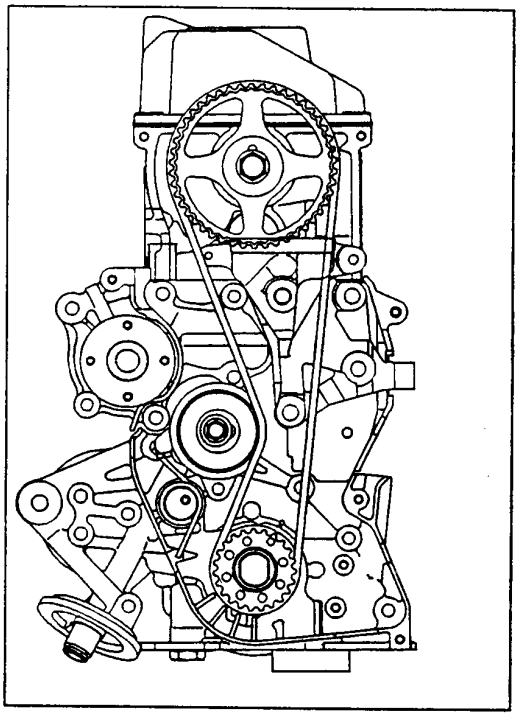


TIMING BELT INSTALLATION

(1) Align the camshaft timing mark with the timing mark on the cylinder head.



(2) Align the crankshaft timing mark with the timing mark on the front case.



(3) Keeping the tension side of the timing belt tight, fit the timing belt onto the crankshaft sprocket, camshaft sprocket, and tensioner pulley in that order.

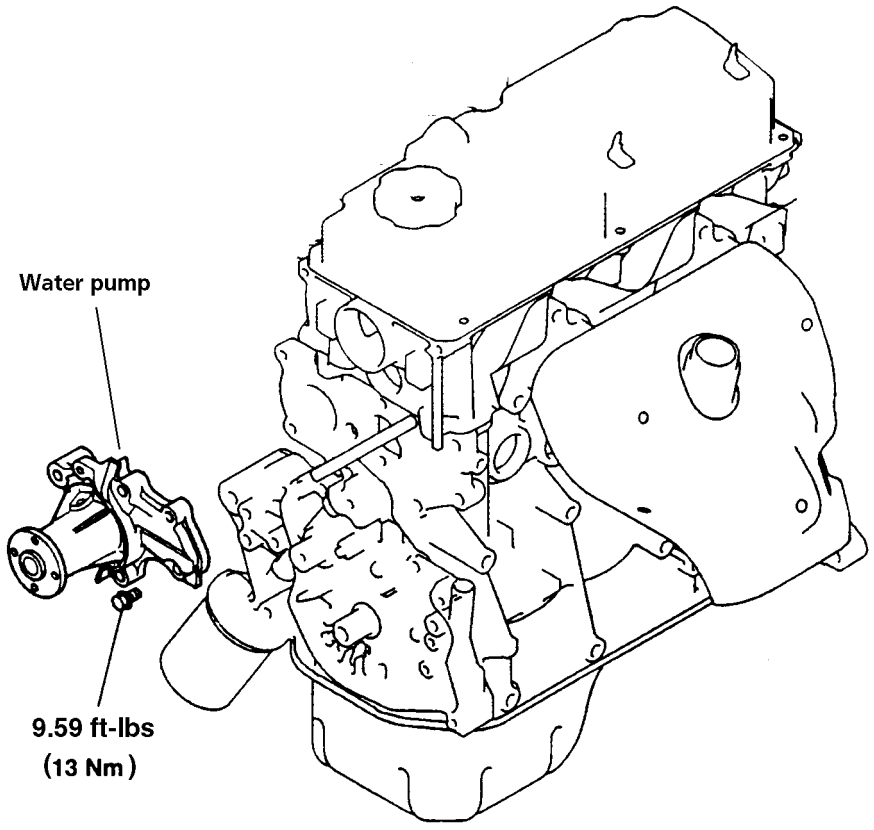
(4) Loosen the tensioner pulley mounting bolts by l/4 to l/2 of a turn and allow the tensioner spring to apply tension to the timing belt.

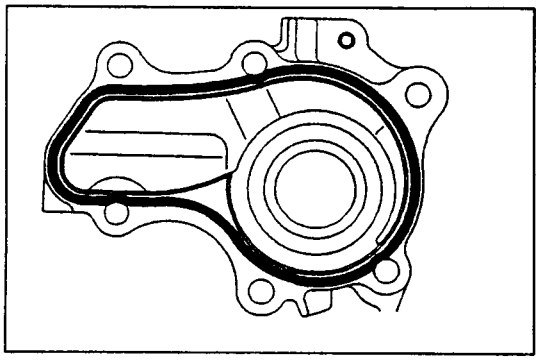
(5) Turn the crankshaft twice in the normal rotating direction (clockwise) and check that the timing marks are correctly aligned.

Caution:
This procedure utilizes the camshaft's driving torque to apply tension evenly to the timing belt. Be sure to turn the crankshaft as described above. Do not turn the crankshaft in reverse.

(6) Tighten the tensioner pulley mounting bolts.

REMOVAL AND INSTALLATION





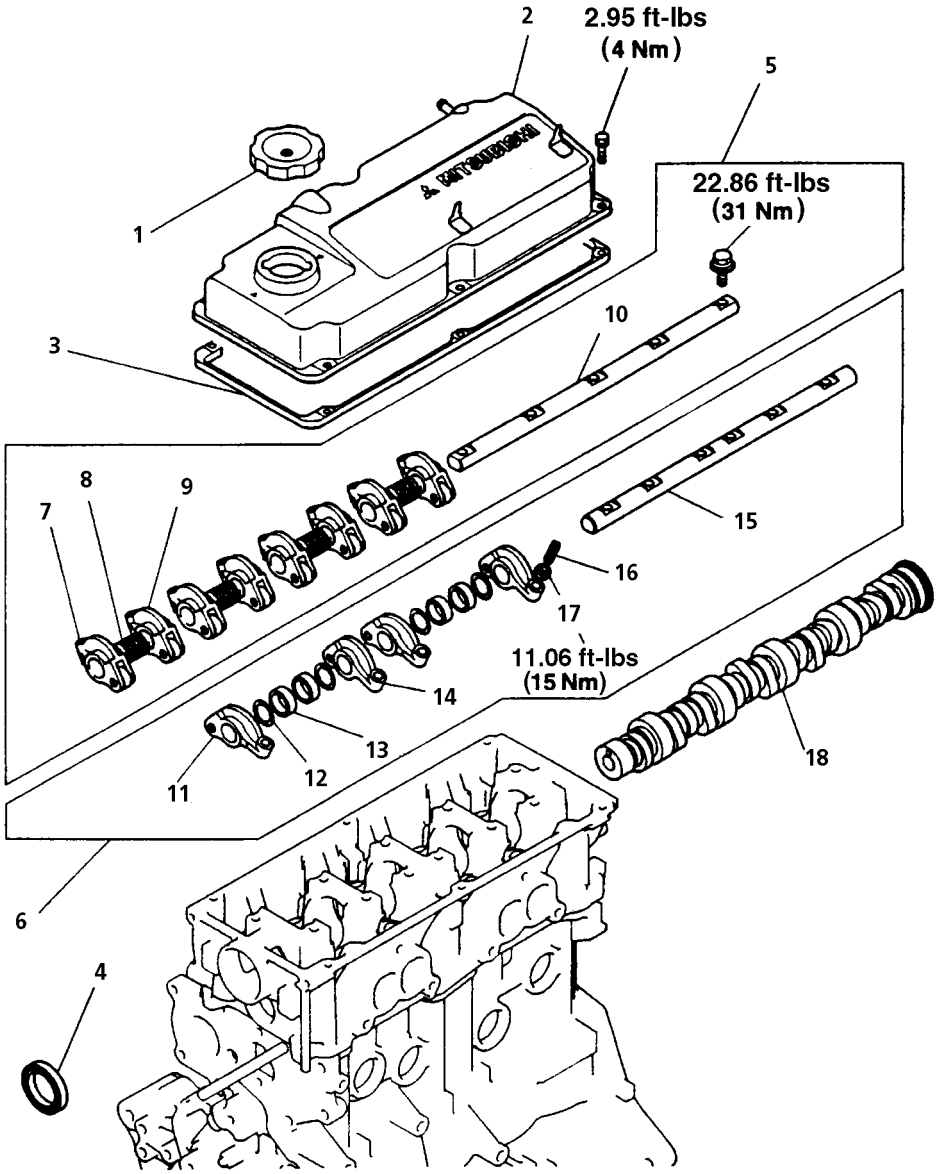
INSTALLATION SERVICE POINTS

WATER PUMP INSTALLATION

(1) Apply a 3 mm bead of form-in-place gasket (FIPG) to the mounting surface.

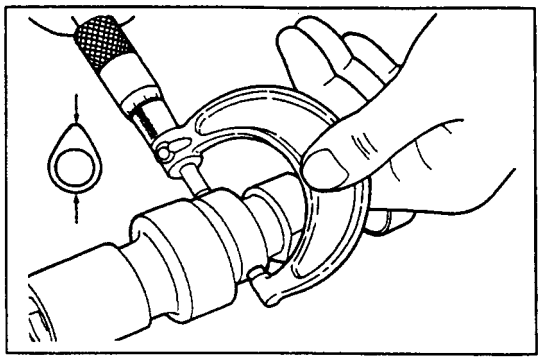
REMOVAL AND INSTALLATION

Apply engine oil to all moving parts before installation.



Removal steps:

1. Oil filler cap
2. Rocker cover
3. Rocker cover gasket
4. Camshaft oil seal
5. Rocker arm and shaft assembly
6. Rocker arm and shaft assembly
7. Rocker arm A
8. Rocker arm spring
9. Rocker arm B
10. Rocker arm shaft
11. Rocker arm C
12. Wave washer
13. Spacer
14. Rocker arm D
15. Rocker arm shaft
16. Adjusting screw
17. Nut
18. Camshaft



INSPECTION

1. CAMSHAFT

(1) Measure the cam heights and replace the camshaft if any height exceeds the specified limit.

Standard value:

Intake: 38.78 mm (1.53 in.)

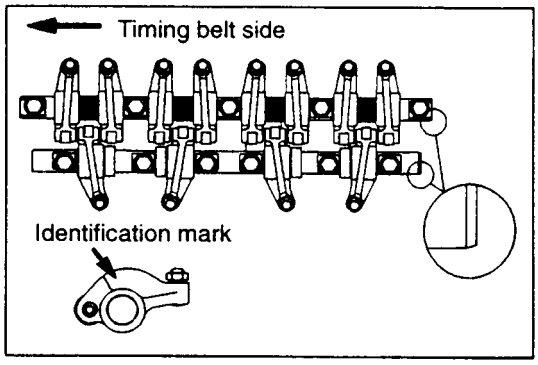
Exhaust: 39.10 mm (1.54 in.)

Limit:

intake: 38.28 mm (1.51 in.)

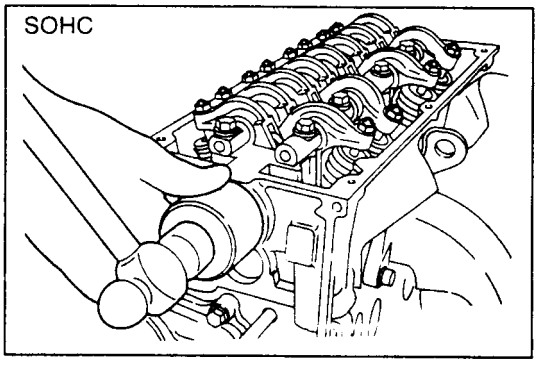
Exhaust: 38.60 mm (1.52 in.)

(2) Reassemble the camshaft into the cylinder head. The end with the dowel pin should face the front of the engine.



ROCKER ARM / ROCKER SHAFT ASSEMBLY INSTALLATION

(1) Assemble the rocker arms and rocker shaft, paying attention to the identification marks. Then, mount the assembly on the cylinder head.



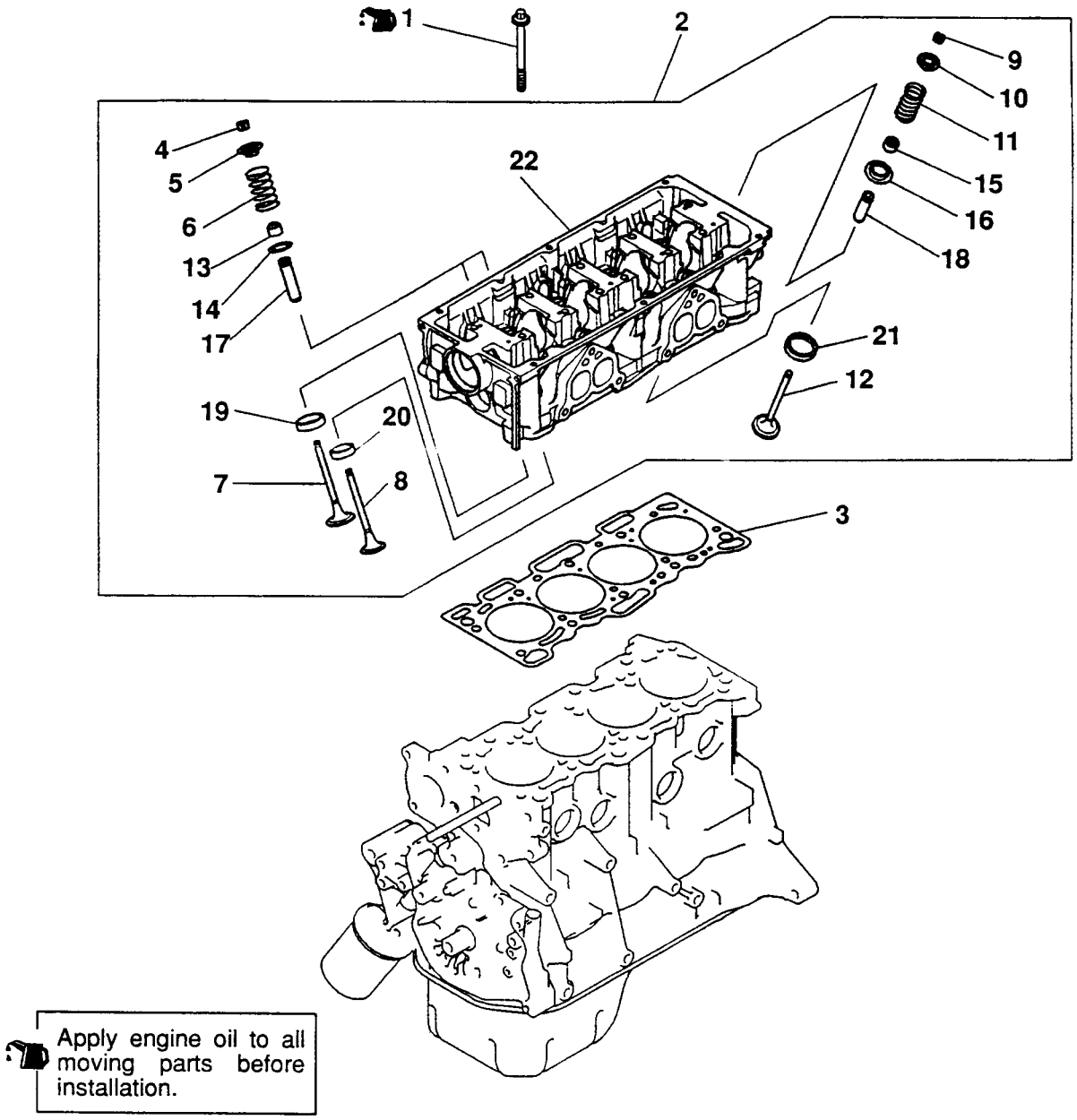
CAMSHAFT OIL SEAL INSTALLATION

Refer to illustration at left.

ROCKER COVER INSTALLATION

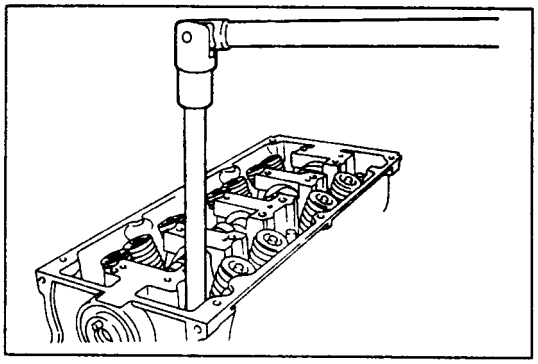
Using a new gasket, install the rocker cover onto the cylinder head. Refer to the exploded view on page 10.

REMOVAL AND INSTALLATION



Removal steps:

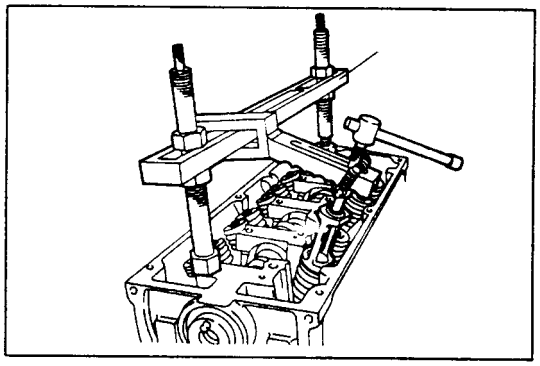
1. Cylinder head bolt
2. Cylinder head assembly
3. Cylinder head gasket
4. Retainer lock
5. Valve spring retainer
6. Valve spring
7. Intake valve (primary)
8. Intake valve (secondary)
9. Retainer lock
10. Valve spring retainer
11. Valve spring
12. Exhaust valve
13. Valve stem seal
14. Valve spring seat
15. Valve stem seal
16. Valve spring seat
17. Intake valve guide
18. Exhaust valve guide
19. Intake valve seat (primary)
20. Intake valve seat (secondary)
21. Exhaust valve seat
22. Cylinder head



REMOVAL SERVICE POINTS

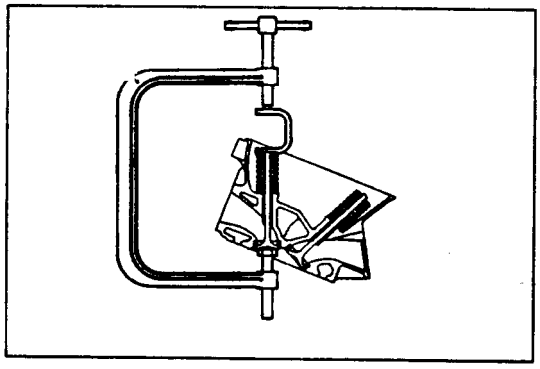
CYLINDER HEAD BOLT REMOVAL

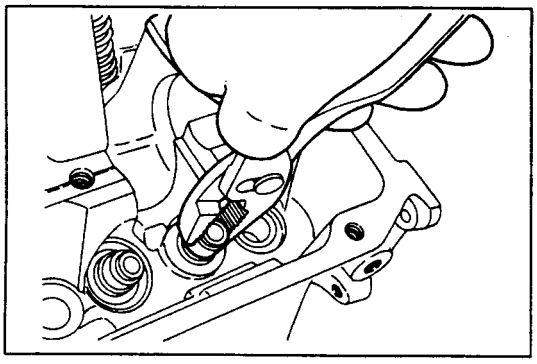
Refer to illustration at left.



RETAINER LOCK REMOVAL

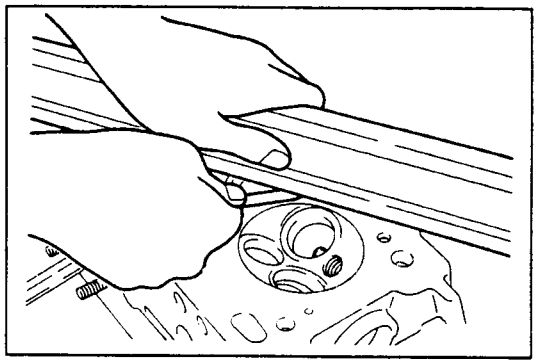
(1) Tag removed valves, springs, and other components, noting their cylinder numbers and locations to facilitate reassembly. Store these components safely.





VALVE STEM REMOVAL

Refer to illustration at left.



INSPECTION

1. CYLINDER HEAD

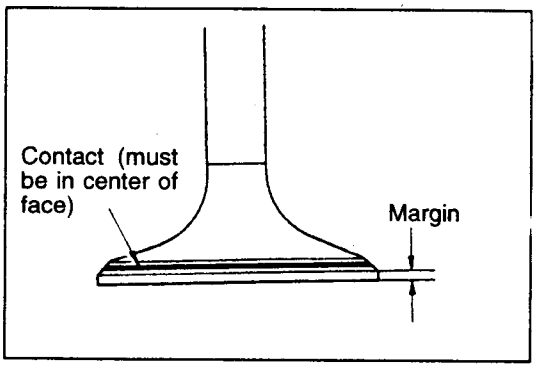
(1) Before cleaning the cylinder head, check it for water leaks, gas leaks, cracks, and other damage.

(2) Remove all oil, water scale, sealant, and carbon. After cleaning the oil passages, blow air through them to verify that they are not blocked.

(3) Check for distortion in the cylinder head gasket surface using a straight edge and thickness gauge. If distortion exceeds the specified limit, grind the gasket surface to specification.

Gasket surface distortion
Standard value: 0.05 mm or less
Limit: 0.2 mm
Grinding limit: 0.2 mm
Cylinder head height (specification when new):
SOHC: 106.9 - 107.1 mm

Caution:
No more than 0.2 mm of stock may be removed from the cylinder head and cylinder block mating surfaces in total.



2. VALVES

(1) Check the valve face for correct contact. If contact is uneven or incomplete, reface the valve seat.

(2) If the margin is less than specified, replace the valve.

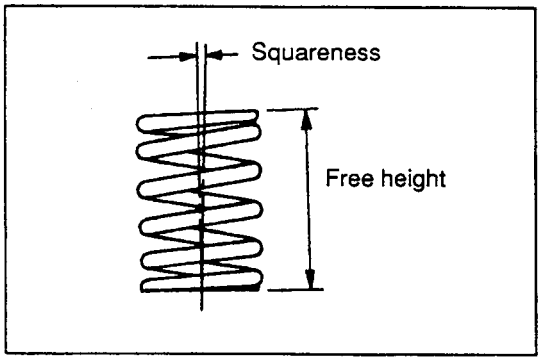
Standard value:
Intake: 1.0 mm
Exhaust: 1.5 mm

Limit:
Intake: 0.5 mm
Exhaust: 1.0 mm

(3) Measure the valve's total length. If the measurement is less than specified, replace the valve.

Standard value:
Intake: 100.75 mm
Exhaust: 101.05 mm

Limit:
Intake: 100.25 mm
Exhaust: 100.55 mm



3. VALVE SPRINGS

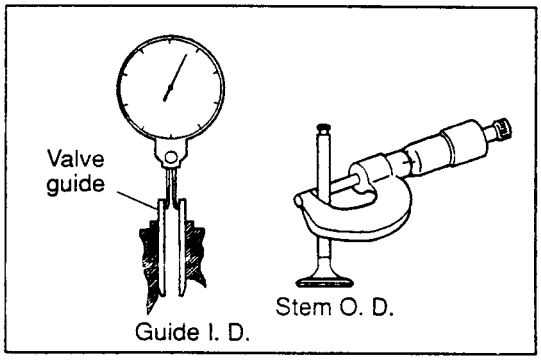
(1) Measure the valve spring's free height. If the measurement is less than specified, replace the spring.

Standard value:
intake: 46.1 mm
exhaust: 46.8 mm

Limit:
exhaust: 46.3 mm

(2) Measure the squareness of the spring. If the measurement exceeds the specified limit, replace the spring.

Standard value: 2° or less
Limit: 4°

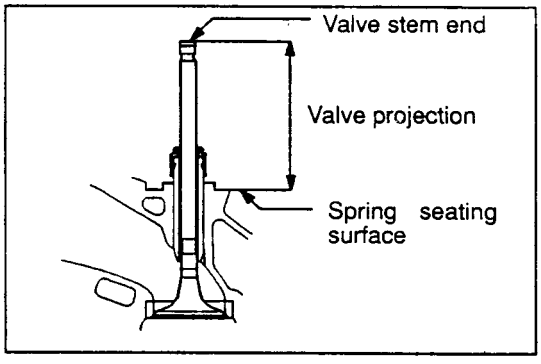


4. VALVE GUIDES

(1) Measure the clearance between the valve guide and valve stem. If the clearance exceeds the specified limit, replace either or both components.

Standard value:
intake: 0.020 - 0.050 mm
exhaust: 0.050 - 0.085 mm

Limit:
Intake : 0.10 mm
Exhaust: 0.15 mm

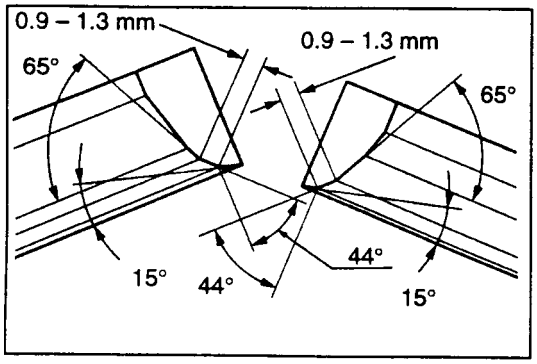


5. VALVE SEATS

(1) Assemble the valve, then measure the valve stem projection between the end of the valve stem and the spring seating surface. If the measurement exceeds the specified limit, replace the valve seat.

Standard value:
intake: 43.70 mm
exhaust: 43.30 mm

Limit:
intake: 44.20 mm
exhaust: 43.80 mm

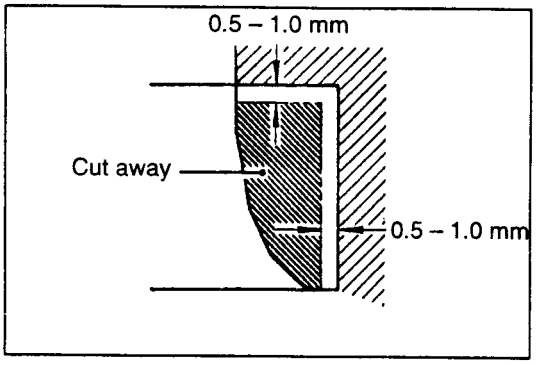


VALVE SEAT CORRECTION SERVICE POINTS

(1) Before correcting the valve seat, check the clearance between the valve guide and valve. If necessary, replace the valve guide.

(2) Using the appropriate special tool or seat grinder, correct the valve seat to achieve the specified seat width and angle.

(3) After correcting the valve seat, lap the valve and valve seat using lapping compound. Then, check the valve stem projection (refer to 5. VALVE SEAT in INSPECTION on page 19).



VALVE SEAT REPLACEMENT SERVICE POINTS

(1) Cut the valve seat to be replaced from the inside to reduce the wall thickness. Then, remove the valve seat.

(2) Rebore the valve seat hole in the cylinder head to match the selected oversize valve seat diameter.

Intake valve seat hole diameters (0.3 O.S.)
- primary: 27.300 - 27.325 mm
- secondary: 32.300 - 32.325 mm

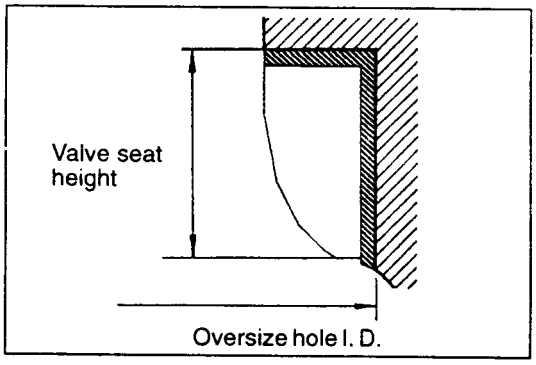
Intake valve seat hole diameters (0.6 O.S)
- primary: 27.600 - 27.625 mm
- secondary: 32.600 - 32.625 mm

Exhaust valve seat hole diameters (0.3 O.S.)
35.300 - 35.325 mm

Exhaust valve seat hole diameters (0.6 O.S.)
35.600 - 35.625 mm

(3) Prevent galling of the cylinder head bore by cooling the valve seat with liquid nitrogen before press-fitting it.

(4) Correct the valve seat to achieve the specified width and angle (refer to VALVE SEAT CORRECTION SERVICE POINTS).



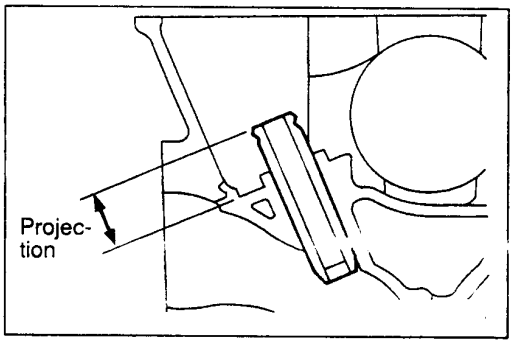
VALVE GUIDE REPLACEMENT SERVICE POINTS

(1) Using a press, push the valve guide out toward the cylinder block side.

(2) Rebore the valve guide hole in the cylinder head to match the oversize valve guide that is to be fitted.

Caution:
Do not install a valve guide of the same size again.

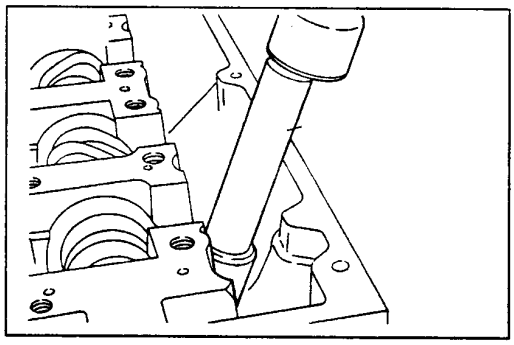
Valve guide hole diameters
0.05 O.S.: 12.050 - 12.068 mm
0.25 OS.: 12.250 - 12.268 mm
0.50 O.S.: 12.500 - 12.518 mm



(3) Press-fit the valve guide until it projects by the specified amount.

Standard value:
17 mm

Caution
1. The valve guide must be installed from the upper side of the cylinder head.
2. The valve guides differ in length on the intake and exhaust sides.
3. After press-fitting the valve guide, insert a new valve and check that it slides smoothly.

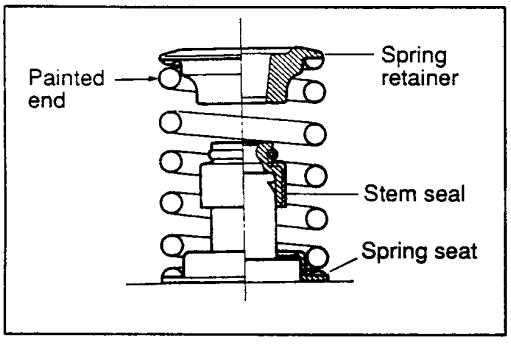


INSTALLATION SERVICE POINTS

VALVE STEM SEAL INSTALLATION

(1) Install the valve spring seat.
(2) Install a new valve stem seal using the special tool shown in the illustration.

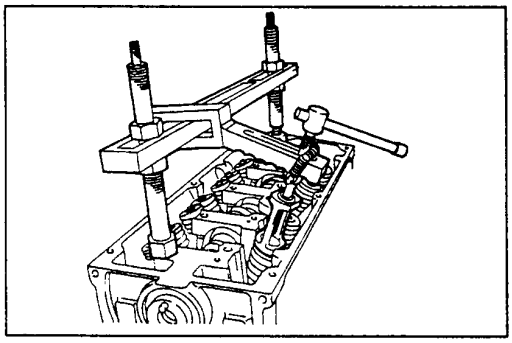
Caution
1. Valve stem seals cannot be reused.
2. The valve stem seal must be installed using the correct special tool. Incorrect installation could result in oil leaking past the valve guide.



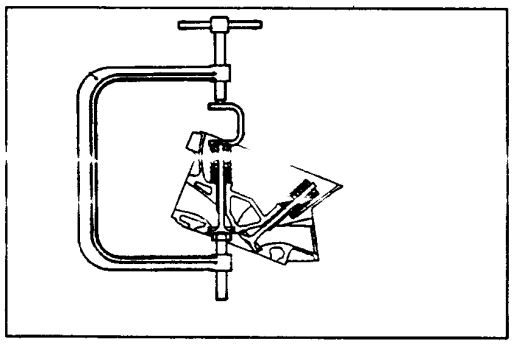
VALVE SPRING INSTALLATION

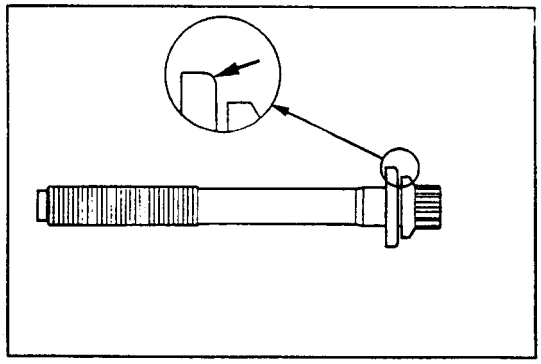
(1) Install the valve spring such that its painted end is on the rocker arm side.

Paint colors:
Intake: Orange
Exhaust: Yellow



RETAINER LOCK INSTALLATION





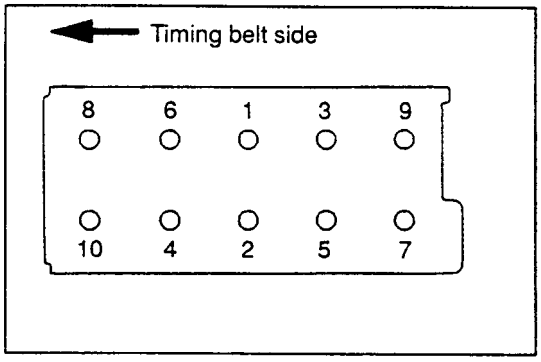
CYLINDER HEAD BOLT INSTALLATION

(1) Before reusing the cylinder head bolt, check that its nominal length does not exceed the specified limit. Replace the bolt if this measurement exceeds the limit.

Limit: 103.2 mm

(2) Fit the washer as shown.

(3) Apply engine oil to the bolt's thread and washer.



(4) Tighten the bolts in the sequence shown until each is torqued to 36.14 ft-lbs (49 Nm).

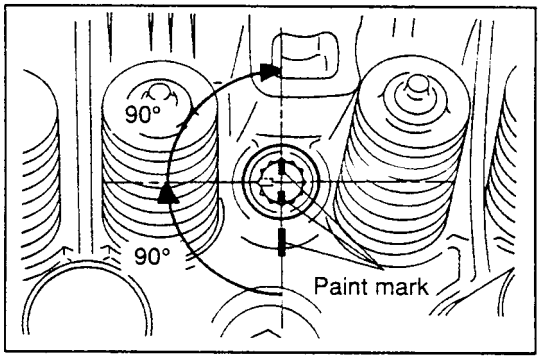
(5) Completely loosen the bolts.

(6) Retighten the bolts in the sequence shown until each is torqued to 14.75 ft-lbs (20 Nm).

(7) Apply paint marks to the cylinder head bolt heads and cylinder head as shown.

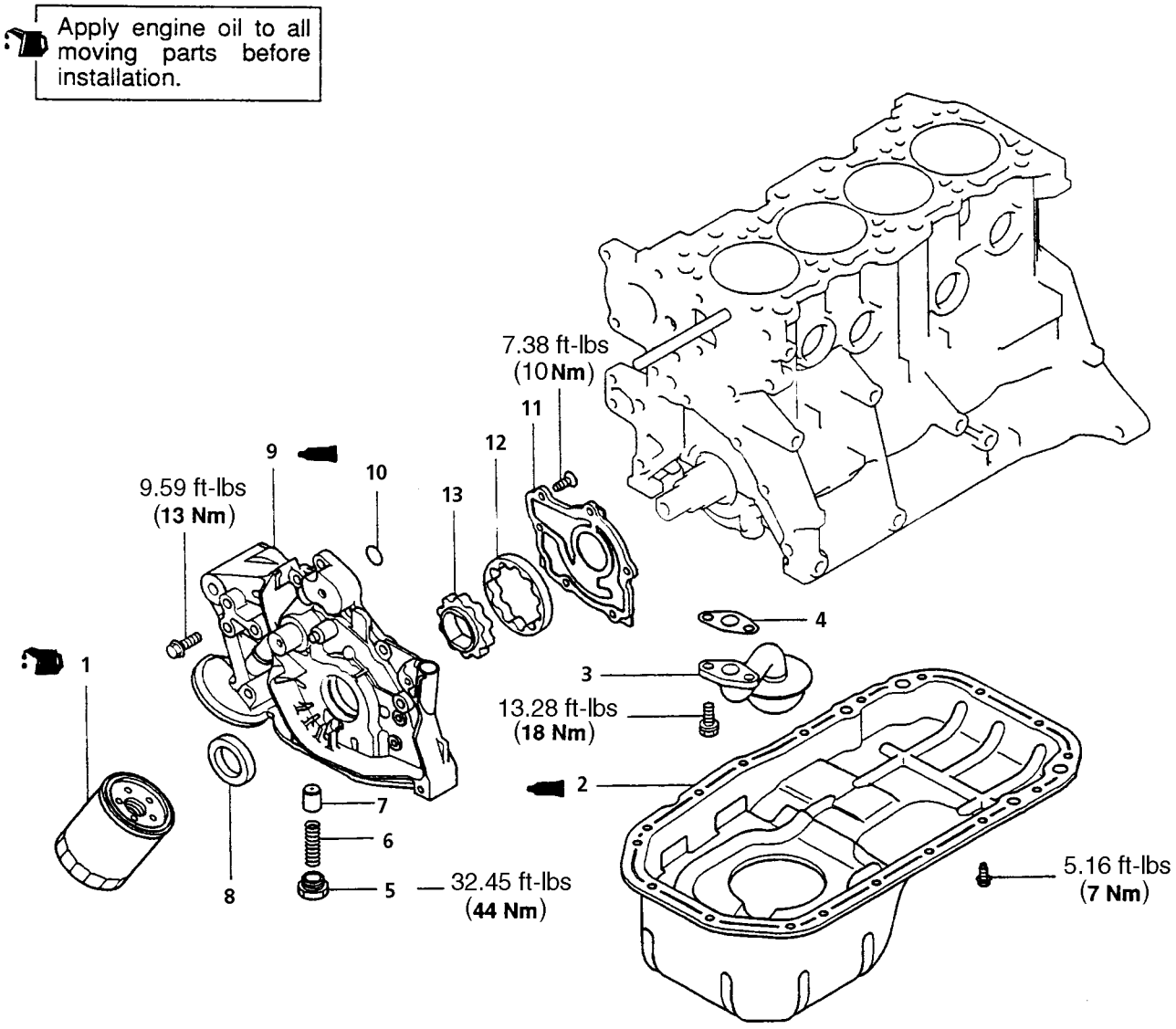
(8) In accordance with the tightening sequence, tighten each bolt by 90°.

(9) Tighten each bolt by a further 90° and check that the paint marks on the bolt head and cylinder head are aligned.



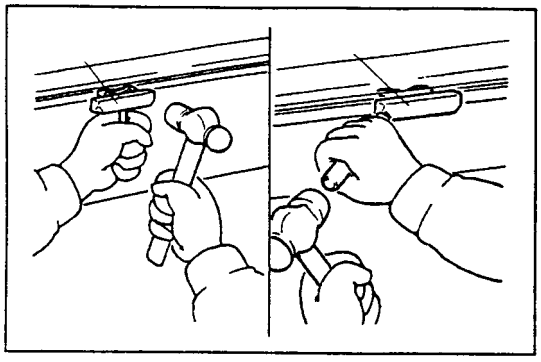
Caution
If the bolts are tightened by an angle of less than 90° they may not hold the cylinder head with sufficient strength.
If the bolts are tightened by an angle exceeding 90°, completely remove them and carry out the installation procedure again.

REMOVAL AND INSTALLATION



Removal steps:

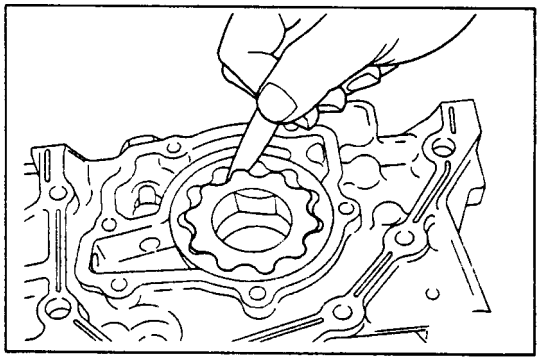
1. **Oil filter**
2. **Oil pan**
3. **Oil screen**
4. **Gasket**
5. **Relief valve**
6. **Relief valve spring**
7. **Relief plunger**
8. **Front oil seal**
9. **Front case**
10. **O-ring**
11. **Oil pump cover**
12. **Oil pump outer rotor**
13. **Oil pump inner rotor**



REMOVAL SERVICE POINTS

OIL PAN REMOVAL

(1) Remove the oil pan mounting bolts.
(2) Knock the special tool between the oil pan and cylinder block as shown in the illustration.
(3) Tapping the side of the special tool, slide the tool along the oil pan/cylinder block seal and thus remove the oil pan.

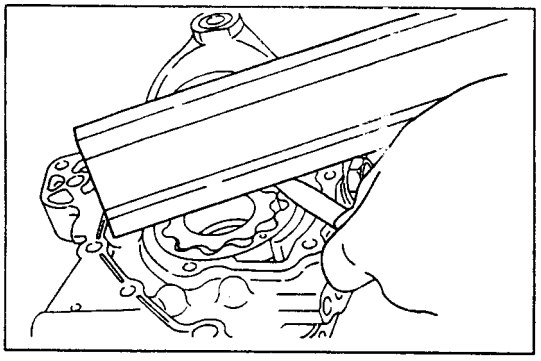


INSPECTION

1. OIL PUMP

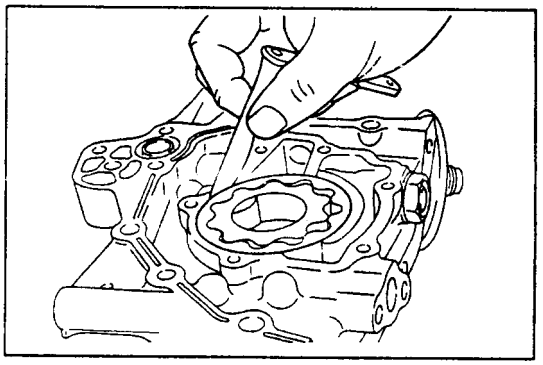
(1) Fit the rotor into the front case.
(2) Check the tip clearance using a thickness gauge.

Standard value: 0.06 - 0.18 mm



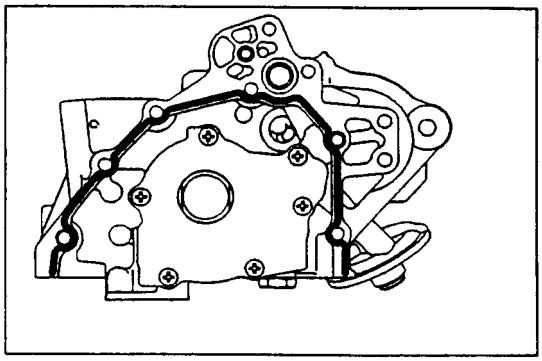
(3) Check the side clearance using a straight edge and thickness gauge.

Standard value: 0.04 - 0.10 mm



(4) Check the body clearance using a thickness gauge.

Standard value: 0.04 - 0.10 mm
Limit: 0.35 mm

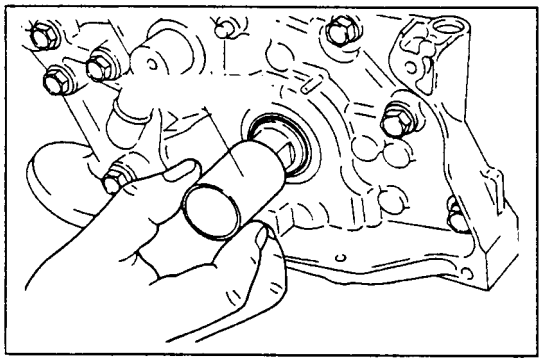


INSTALLATION SERVICE POINTS

FRONT OIL SEAL CASE INSTALLATION

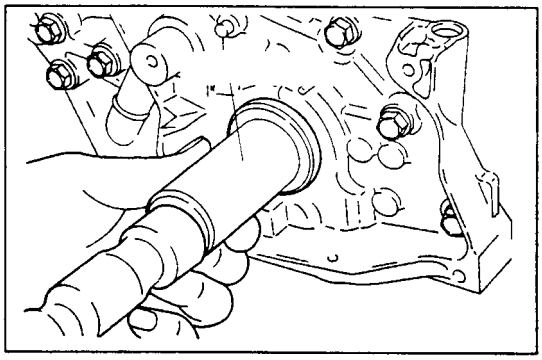
(1) Clean the sealant application surfaces on the cylinder block and front oil seal case.

(2) Apply a 3 mm bead of form-in-place gasket to the entire circumference of the oil pan flange.

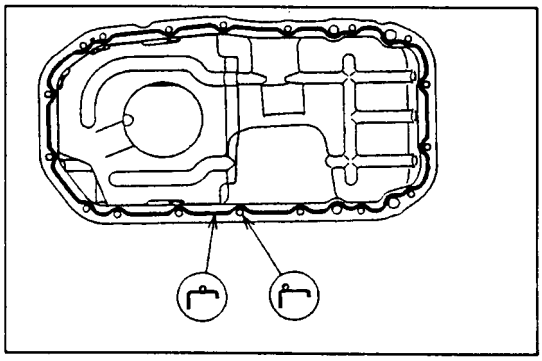


FRONT OIL SEAL INSTALLATION

(1) Place the special toolon the crankshaft's front end and apply engine oil to the its outer circumference.



(2) Apply engine oilto the oil seal lip, then push the oil seal along the guideby hand until it touches the front case. Tap the oil sealinto place using the special tool.



OIL PAN INSTALLATION

(1) Clean the mating surfaces of the cylinder block and oil pan.

(2) Apply a 4 mm bead of form-in-place gasket to the outer circumference of the oil pan flange.

OIL FILTER INSTALLATION

(1) Clean the filter mounting surface on the front case.

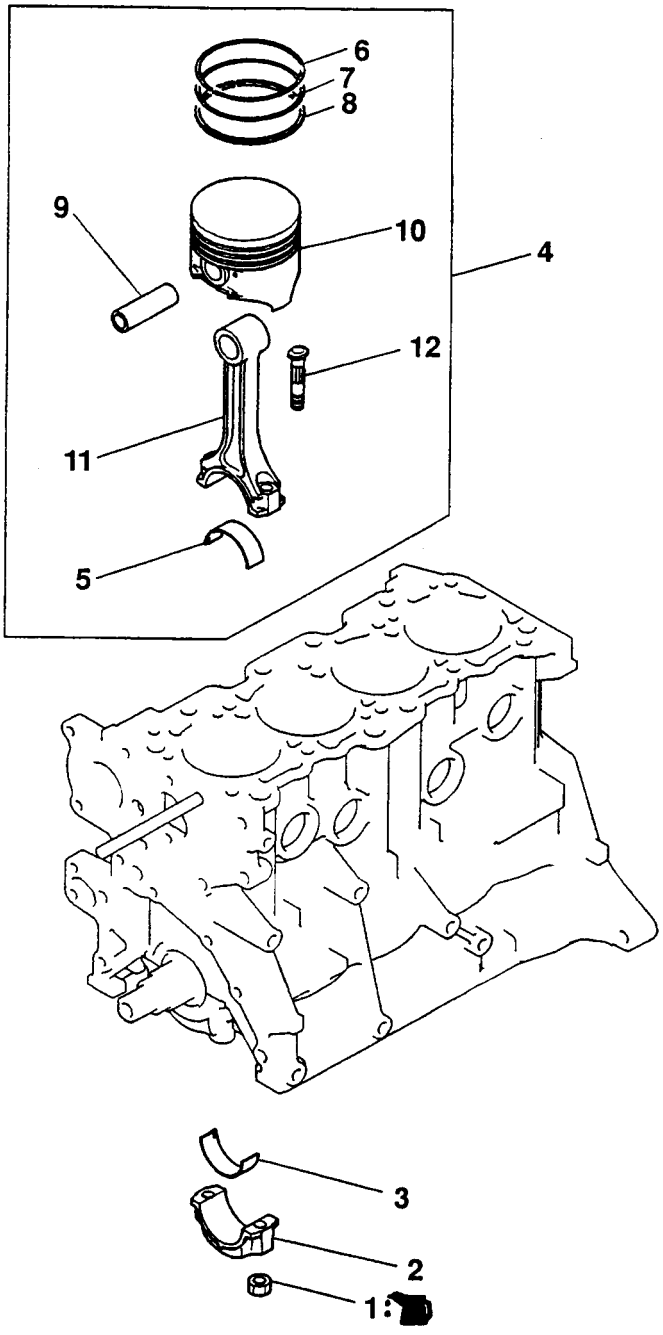
(2) Apply engine oil to the oil filter's O-ring.

(3) Screw on the oil filter until the O-ring is seated on the mounting surface. Then, give the oil filter one further turn such that it is torqued to approximately 10.33 ft-lbs (14 Nm).

Caution
The oil filter must be tightened using a commercially available filter wrench. If the filter is tightened by hand only, it will be insufficiently torqued, resulting in oil leaks.

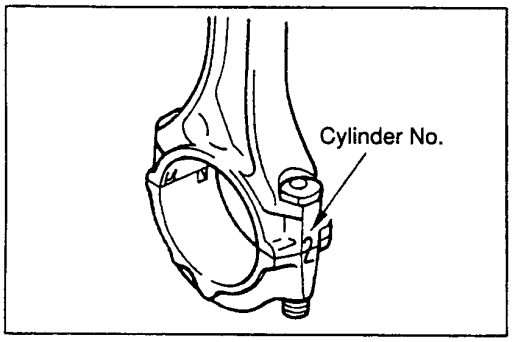
REMOVAL AND INSTALLATION

Apply engine oil to all moving parts before installation.



Removal steps:

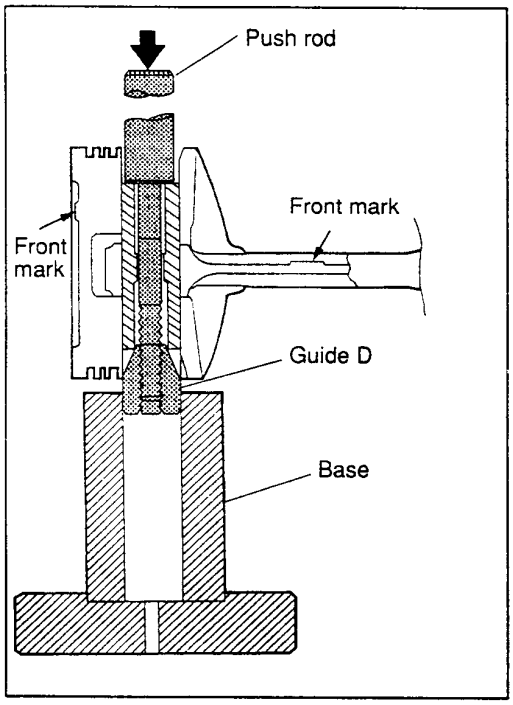
1. Connecting rod nut
2. Connecting rod cap
3. Connecting rod bearing
4. Piston and connecting rod assembly
5. Connecting rod bearing
6. Piston ring No. 1
7. Piston ring No. 2
8. Oil ring
9. Piston pin
10. Piston
11. Connecting rod
12. Bolt



REMOVAL SERVICE POINTS

CONNECTING ROD CAP REMOVAL

(1) Mark the cylinder number on the side of the connecting rod big end to facilitate reassembly.



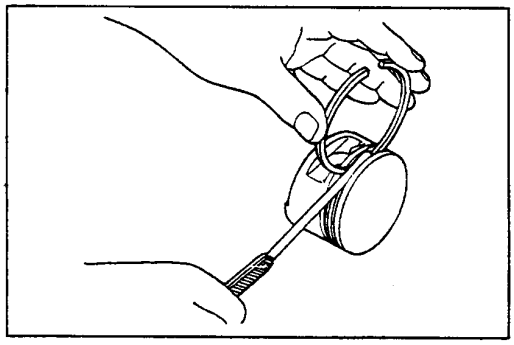
PISTON PIN REMOVAL

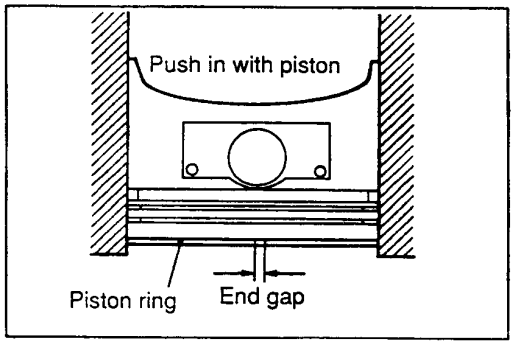
(1) Insert the Push Rod (special tool) from the front arrow mark side, then fit guide D.

(2) Mount the piston and connecting rod assembly on the Piston Pin Setting Base (special tool) with the piston's front mark pointing upward.

(3) Remove the piston pin using a press.

NOTE
After removing the piston pin, keep the piston, piston pin, and connecting rod together. Do not allow pistons, piston pins, and connecting rods from different cylinders to become mixed up.





INSPECTION

1. PISTON RINGS

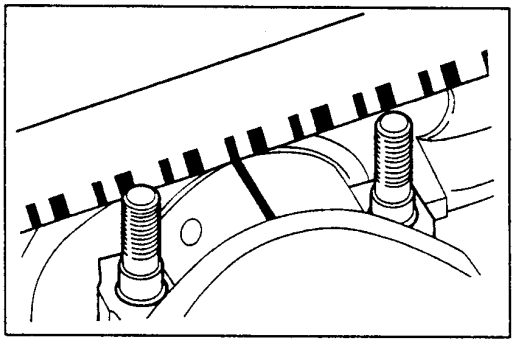
(1) Check the piston ring side clearance. If the clearance exceeds the specified limit, replace the ring or piston, or both.

Standard values:
No. 1 ring: 0.03 - 0.07 mm
No. 2 ring: 0.02 - 0.06 mm

(2) Insert the piston ring into the cylinder bore and push it down with a piston. Ensure that the piston's crown is in contact with the ring such that the ring is at 90° to the cylinder wall. Then, measure the end gap with a thickness gauge. If the gap is too large, replace the piston ring.

Standard values:
No. 1 ring: 0.20 - 0.35 mm
No. 2 ring: 0.35 - 0.50 mm
Oil ring: 0.20 - 0.50 mm

Limits:
No. 1 ring: 0.8 mm
No. 2 ring: 0.8 mm
Oil ring: 1.0 mm



2. CRANKSHAFT PIN OIL CLEARANCE (PLASTIC

(1) Wipe all oil off the crankshaft pin and connecting rod bearing.
(2) On the pin, place a plastic gauge that is cut to the same length as the bearing's width. The plastic gauge must be centered on the pin in parallel with the pin's axis.
(3) Gently place the connecting rod cap in position and tighten the bolts to the specified torque.
(4) Remove the bolts and gently remove the connecting rod cap.
(5) Measure the compressed part of the plastic gauge at its widest point using the scale printed on the plastic gauge bag.

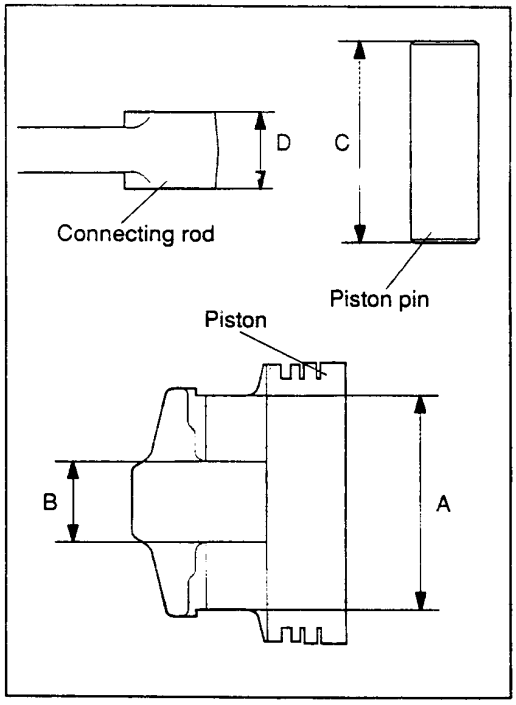
Standard value: 0.02 - 0.04 mm
Limit: 0.1 mm

INSTALLATION SERVICE POINTS

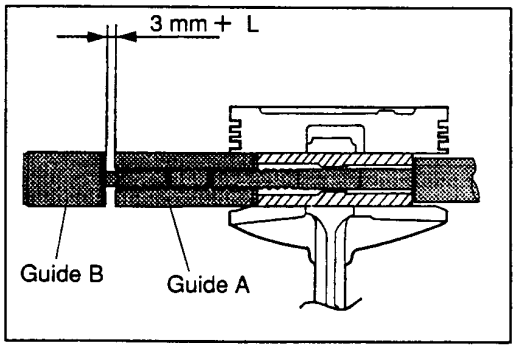
PISTON PIN INSTALLATION

(1) Measure the following lengths (as shown):
A: Piston boss-to-piston boss outside dimension
B: Piston boss-to-piston boss inside dimension
C: Piston pin length
D: Connecting rod small end eye thickness
(2) Enter the measured values into the following formula:

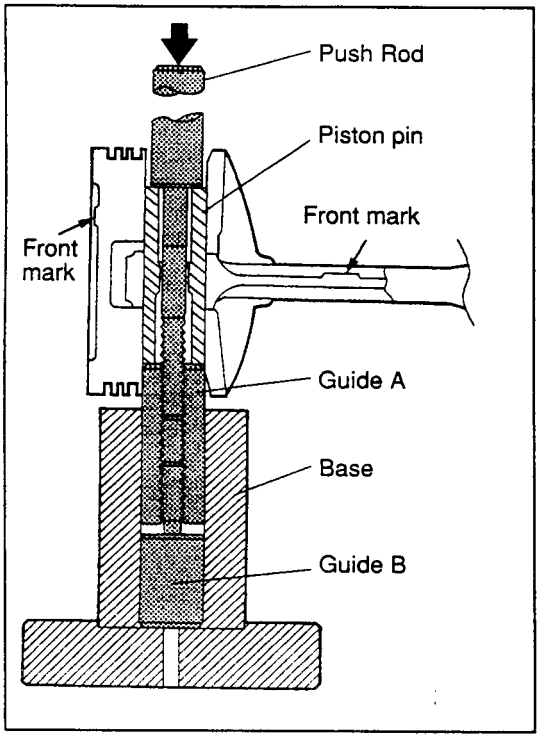
$$L = \frac{(A - C) - (B - D)}{2}$$



(3) Insert the Push Rod (special tool) into the piston pin, then fit Guide A (special tool).
(4) Fit the piston and connecting rod together such that their front marks are on the same side.
(5) Apply engine oil to the outside of the piston pin.
(6) Into the front-mark side of the piston, insert the Guide A, piston pin, and Push Rod, starting with guide A.



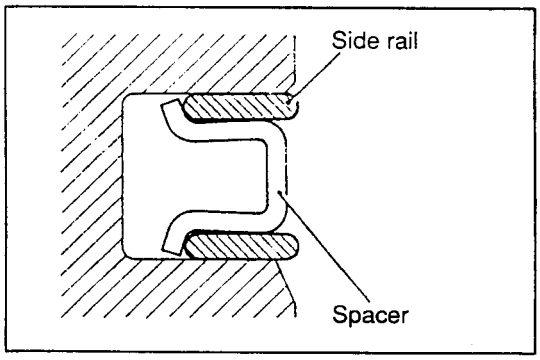
(7) Screw guide B into guide A. Leave a gap between the two guides of 3 mm plus the value (L) calculated in step (2).

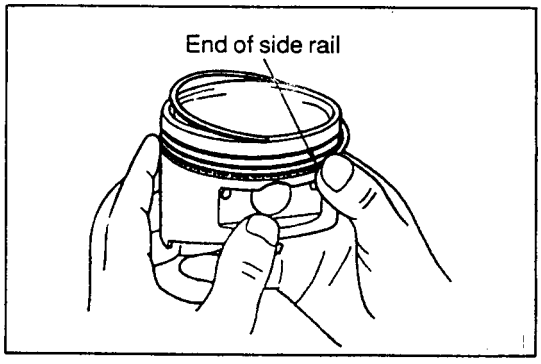


(8) Mount the piston and connecting rod on the Piston Pin Setting Base (special tool) with the piston's front mark pointing upward.

(9) Install the piston pin using a press. If the press-fitting load is out of specification, replace the piston pin and piston assembly or the connecting rod, or both.

Standard value: 4,900 - 14,700 N (1101 to 3303 pounds)





OIL RING INSTALLATION

(1) Fit the oil ring spacer into the piston ring groove. Then, fit the upper and lower side rails.

NOTE:

(1) The spacer and side rails may be fitted in either direction. No distinction is made between top and bottom.

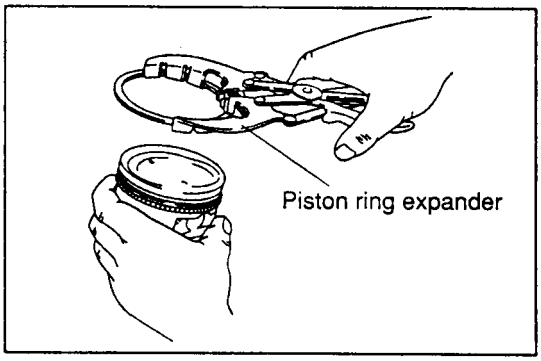
(2) Spacer and side rail sizes are color-coded as follows:

Size	Color
STD	None
0.50 mm O. S.	Blue
1 .00 mm O. S.	Yellow

(2) To install a side rail, fit one end of the rail into the groove then press the rest of the rail into position by hand as shown.

Caution
Do not fit side rails using a piston ring expander since they may break.

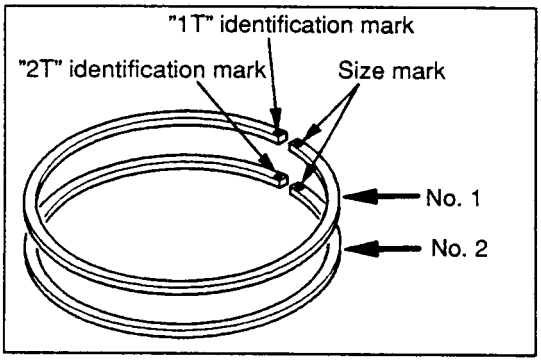
(3) After installing the side rails, check that they move smoothly in both directions.



PISTON RING No. 2 / PISTON RING No. 1 INSTALLATION

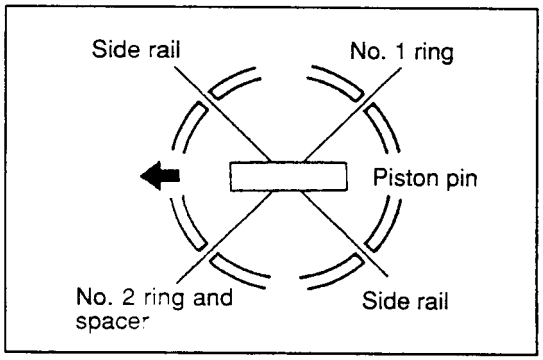
(1) Using a ring expander, fit ring No. 2 and ring No. 1 with their identification marks facing upward (on the piston crown side).

Identification marks:
No. 1 ring: 1T
No. 2 ring: 2T



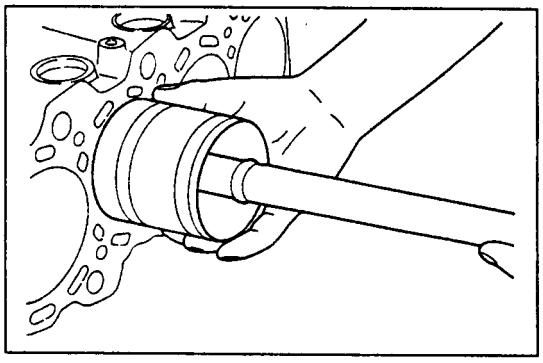
NOTE:
Piston rings are stamped with size marks as follows:

Size	Size mark
STD	None
0.50 mm O. S.	50
1 .00 mm O. S.	100

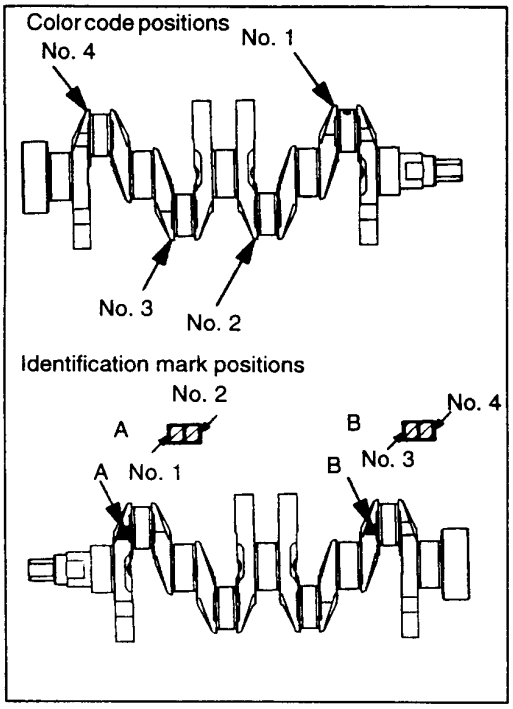


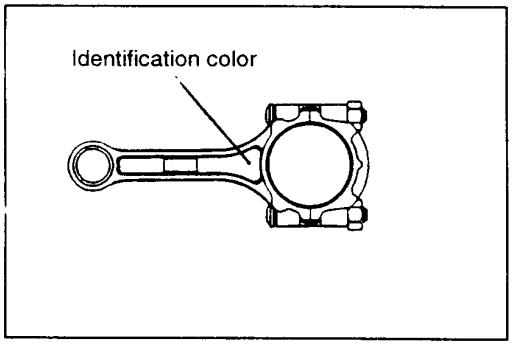
PISTON AND CONNECTING ROD ASSEMBLY INSTALLATION

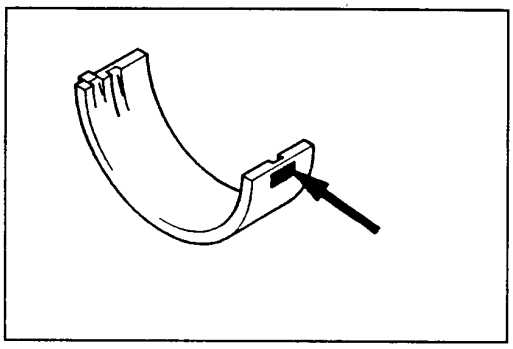
(1) Apply oil to the piston, piston rings, and oil ring.
(2) Align the gaps of the piston rings and oil ring (side rails and spacer) as shown.
(3) With the piston crown's front arrow mark pointing toward the timing belt side, press the pistonand connecting rod assembly into the cylinder from the top of the cylinder.

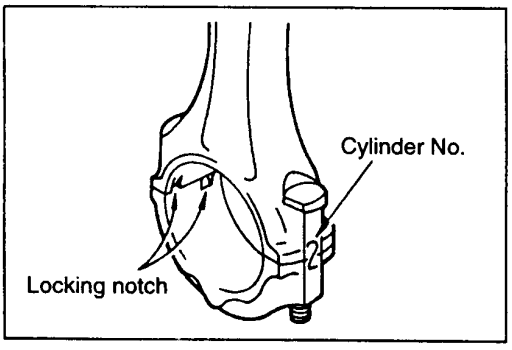


(4) Compress the piston rings tightly with a suitable ring compression tool, then press the piston and connecting rod fully into the cylinder. Do not strike the piston hard since the piston rings may break and the crank pin may be nicked.









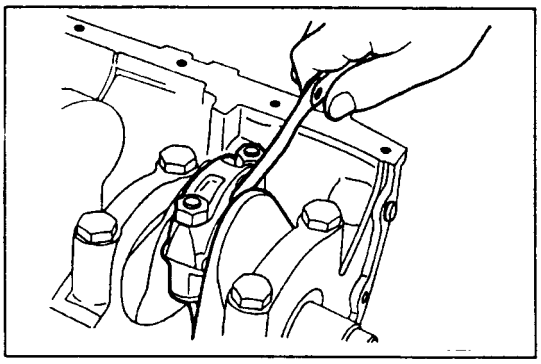
CONNECTING ROD BEARING INSTALLATION

(1) Select bearings according to the crankshaft and connecting rod identification marks or color codes, referring to the following table.

Crankshaft identification mark	Connecting rod identification color	Bearing identification mark
I, Yellow	White	1
	None	1
	Yellow	2
II, None	White	1
	None	2
	Yellow	3
III, White	White	2
	None	3
	Yellow	3

CONNECTING ROD CAP INSTALLATION

(1) Aligning the marks made during disassembly, fit the bearing cap onto the connecting rod. If the connecting rod is new and has no index mark, ensure that the bearing locking notches are both on the same side.



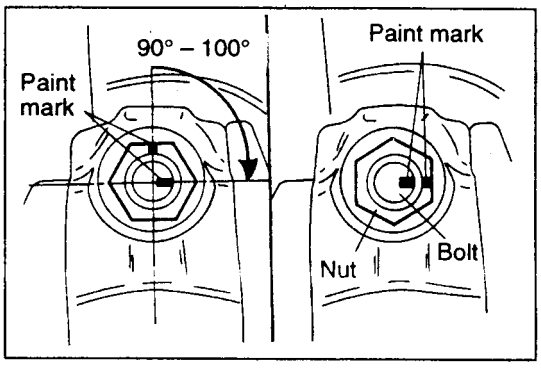
(2) Check that the connecting rod big end side clearance confirms with specifications.

Standard value: 0.10 - 0.25 mm
Limit: 0.4 mm

CONNECTING ROD CAP NUT INSTALLATION

Caution
To fit the connecting rod cap nuts with the cylinder head in place, the spark plugs must be removed beforehand.

(1) The connecting rod bolts and nuts utilize the plastic region tightening method. The bolts must therefore be checked for stretching before reuse. To check a bolt for stretching, screw the nut down the entire length of the thread by hand. Unless the nut turns smoothly all the way, the bolt's threaded section is stretched and the bolt must be replaced.

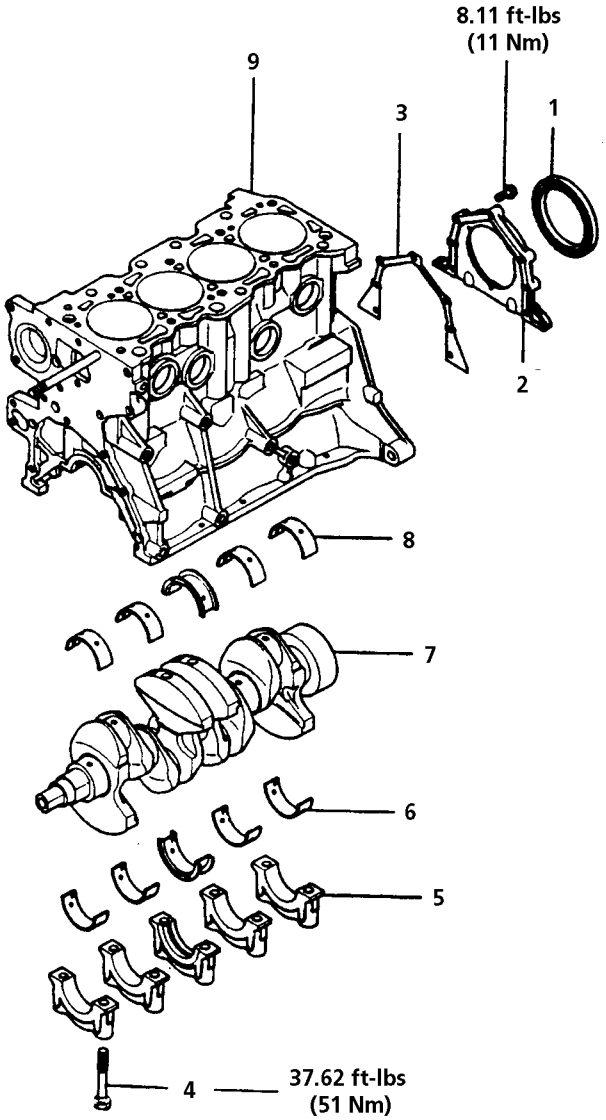


(2) Before fitting the nuts, apply engine oil to their threads and seating surfaces.
(3) Fit the nuts onto the bolts and turn them until they are finger-tight. After this,the nuts must be tightened alternately to ensure correct fitting of the cap.
(4) Tighten the nuts to a torque of 12.54 ft-lbs (17 Nm).
(5) Make a paint mark on the top of each nut as shown.
(6) Make paint marks on the bolts 90 to 100° clockwise from the paint marks on the nuts.
(7) Turn the nuts until their paint marks are aligned with the paint marks on the bolts.

Caution
1. If the nuts are turned by less than 90°, the cap may not be held on with sufficient strength.
2. If the nuts are turned by more than 100°, loosen them completely and carry out the tightening procedure again.

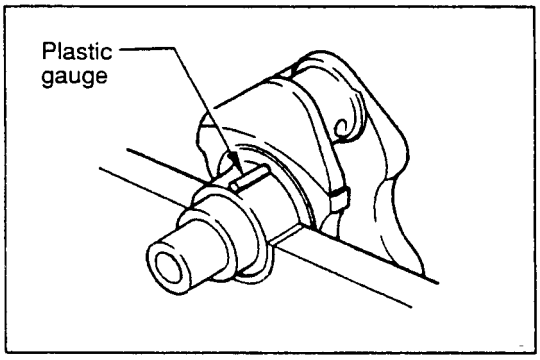
REMOVAL AND INSTALLATION

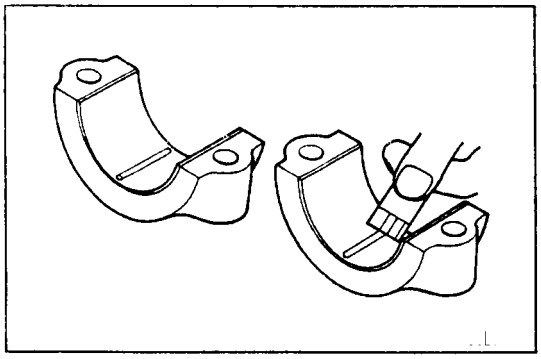
Apply engine oil to all moving parts before installation.



Removal steps:

1. Rear oil seal
2. Rear oil seal case
3. Rear oil seal case gasket
4. Bearing cap bolt
5. Bearing cap
6. Crankshaft bearing (lower)
7. Crankshaft
8. Crankshaft bearing (upper)
9. Cylinder block





INSPECTION

1. CRANKSHAFT OIL CLEARANCE

The crankshaft oil clearance can be measured easily using a plastic gauge.

To check the crankshaft oil clearance with a plastic gauge, carry out the following procedure:

(1) Wipe all oil off the crankshaft journal and the bearing's inside surface.

(2) Install the crankshaft.

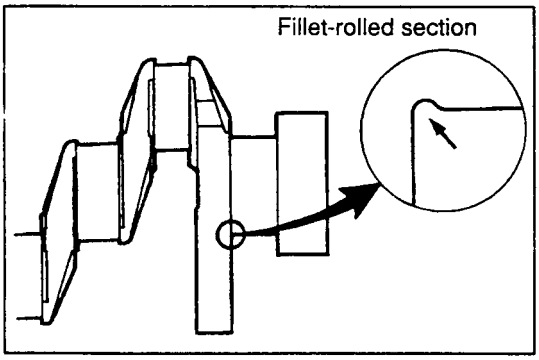
(3 Cut the plastic gauge such that its length matches the width of the bearing, then place it on the journal along the journal's axis.

(4) Gently fit the crankshaft bearing cap and tighten the bolts to the specified torque.

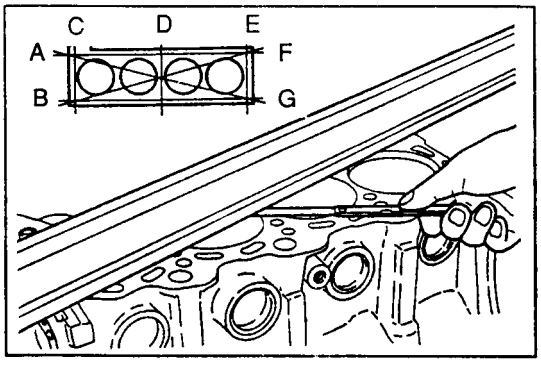
(5) Remove the bolts and gently remove the crankshaft bearing cap.

(6) Using the scale printed on the plastic gauge bag, measure the plastic gauge's crushed section at its widest point.

Standard value: 0.02 - 0.04 mm
Limit: 0.1 mm



NOTE
The crankshaft pins and journals are fillet-rolled and must not be machined to undersize dimensions.



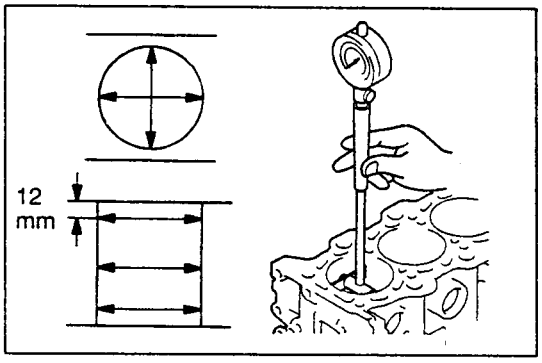
2. CYLINDER BLOCK

(1) Visually check for cracks, rust, and corrosion, and inspect the cylinder block using a flaw detecting agent. Rectify defects where possible or replace the cylinder block.

(2) Ensure that the top surface is free of gasket chips and other foreign material. Check the cylinder block's top surface for distortion using a straight edge and thickness gauge.

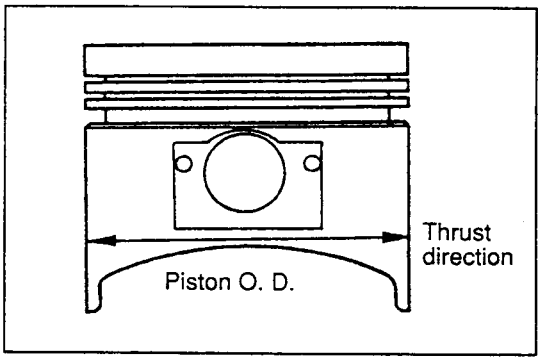
Standard value: 0.05 mm
Limit: 0.1 mm

(3) Check the cylinder walls for cracks and seizure marks. If defects are evident, bore all the cylinders to oversize or replace the cylinder block.



(4) Using a cylinder gauge, measure each cylinder's bore and cylindricity. If any cylinder is severely worn, bore all the cylinders to oversize and replace the piston and piston rings accordingly. Take measurements at the points shown.

Standard value:
Cylinder bore: 75.5 mm
Cylindricity: 0.01 mm or less



3. BORING CYLINDERS

(1) Oversize pistons to be used should be determined on the basis of the cylinder with the largest bore.

(2) Oversize pistons are available with the following oversize dimensions: 0.25 mm, 0.50 mm, 0.75 mm, and 1.00 mm. Measure the diameter of the piston to be used. Boring must be carried out such that the piston-to-cylinder clearance complies with the standard value. The piston's diameter should be measured at the points shown.

(3) Calculate the boring finish dimension based on the piston diameter dimension.

- [Boring finish dimension] = [piston O.D.] + [piston-to-cylinder clearance (0.02 - 0.04 mm)] - [honing margin (0.02 mm)]

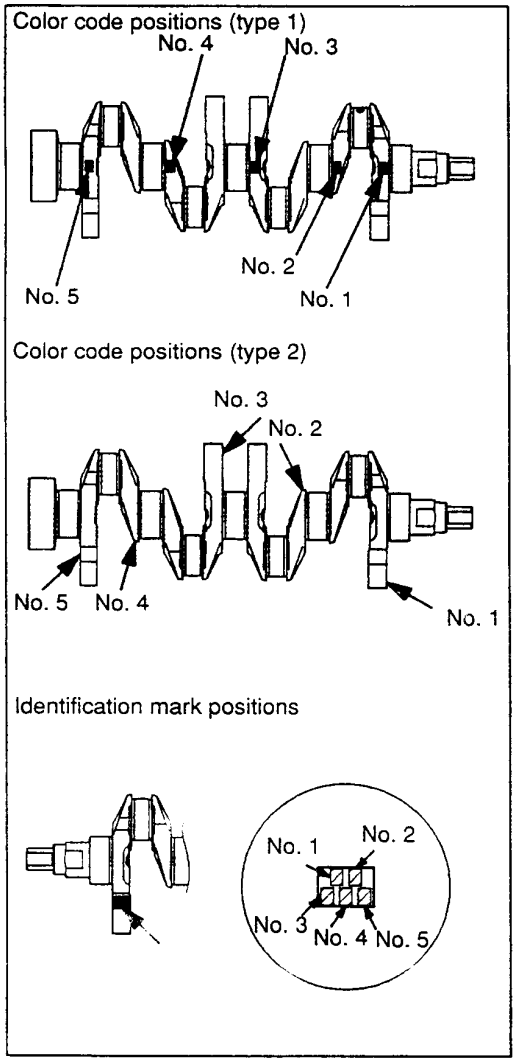
(4) Bore each cylinder to the calculated boring finish dimension.

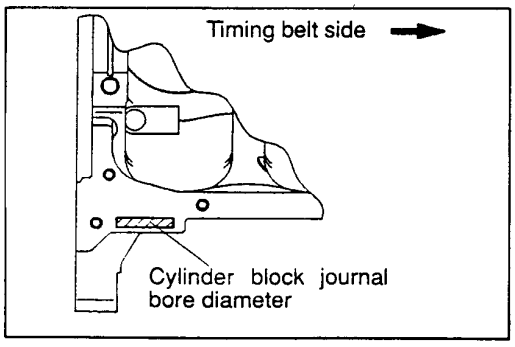
Caution
To prevent distortion caused by heat increases during boring bore the cylinders in the following order: No. 2, No. 4, No. 1, No. 3.

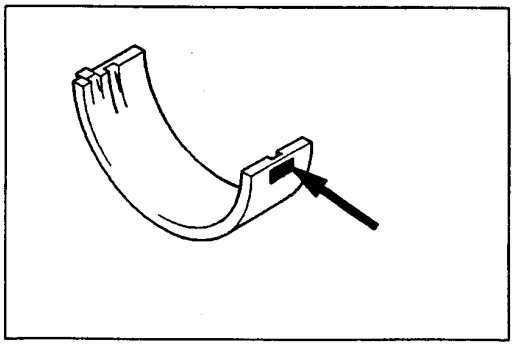
(5) Hone the cylinders to the final finish dimension (piston O.D. + piston-to-cylinder clearance).

(6) Check the clearance between the pistons and cylinders.

Standard value: 0.02 - 0.04 mm







CRANKSHAFT BEARING INSTALLATION

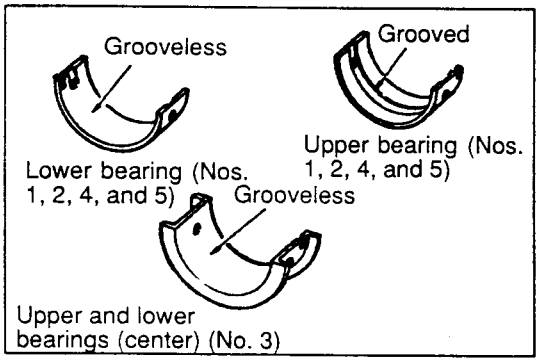
(1) Select bearings according to the crankshaft identification marks or color codes, referring to the following table. If they are not identifiable, measure the crankshaft journals and choose bearings to match the measurements.

Crankshaft journal				Cylinder block bearing bore diameter	Bearing
Range	Color code	Identification mark	Journal diameter mm	Identification mark	Identification mark
1	Yellow	I	47.995 -48.000	0	1
				1	2
				2	3
2	None	II	47.985 -47.995	0	2
				1	3
				2	4
3	White	III	47.980 -48.985	0	3
				1	4
				2	5

(2) Identification marks showing the cylinder block bearing bore diameter are stamped in the position shown, with No. 1 at the front of the engine. Bearings must be selected and installed in accordance with these identification marks.

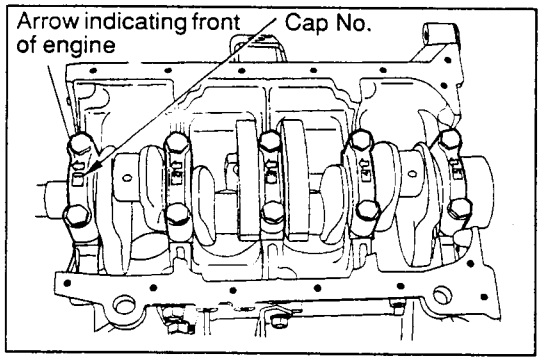
(3) Based on the identification markings verified in steps (1) and (2), select bearings from table above. See the following example:

1. If the measured crankshaft journal diameter is 48.000 mm, this corresponds to classification 1 in the above table.
2. If the identification mark on the cylinder block bearing hole is "1", select a bearing with an identification mark of "2".


Grooveless
Grooved
Upper bearing (Nos. 1, 2, 4, and 5)
Lower bearing (Nos. 1, 2, 4, and 5)
Grooveless
Upper and lower bearings (center) (No. 3)

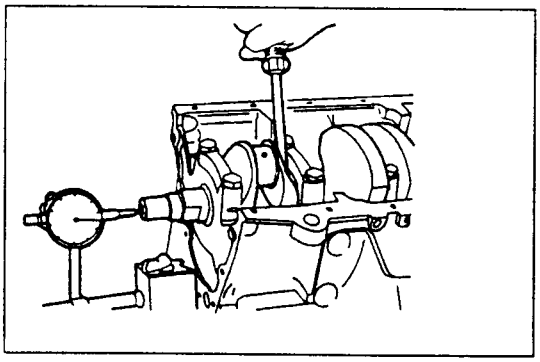
(4) Except for the center bearing, all the upper bearings are grooved. The center bearings are grooveless and have flanges. The center bearings are the same at the top and bottom.

(5) The lower bearings are all grooveless.



BEARING CAP INSTALLATION

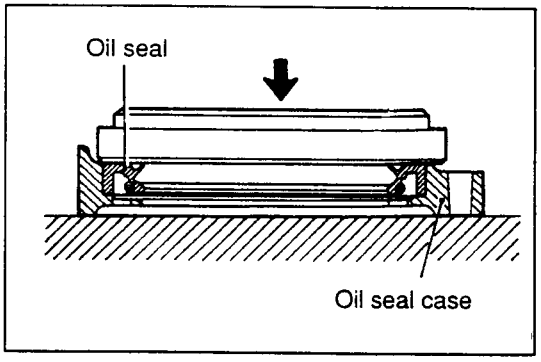
(1) On the bottom surface of each bearing cap is the cap's number and an arrow. Starting at the timing belt side, fit the bearing caps in numerical order. Ensure that the arrows point toward the timing belt side.



(2) After fitting the bearing caps, measure the end play in the crankshaft. If the measurement exceeds the specified limit, replace the crankshaft bearings.

Standard value: 0.05 - 0.18 mm

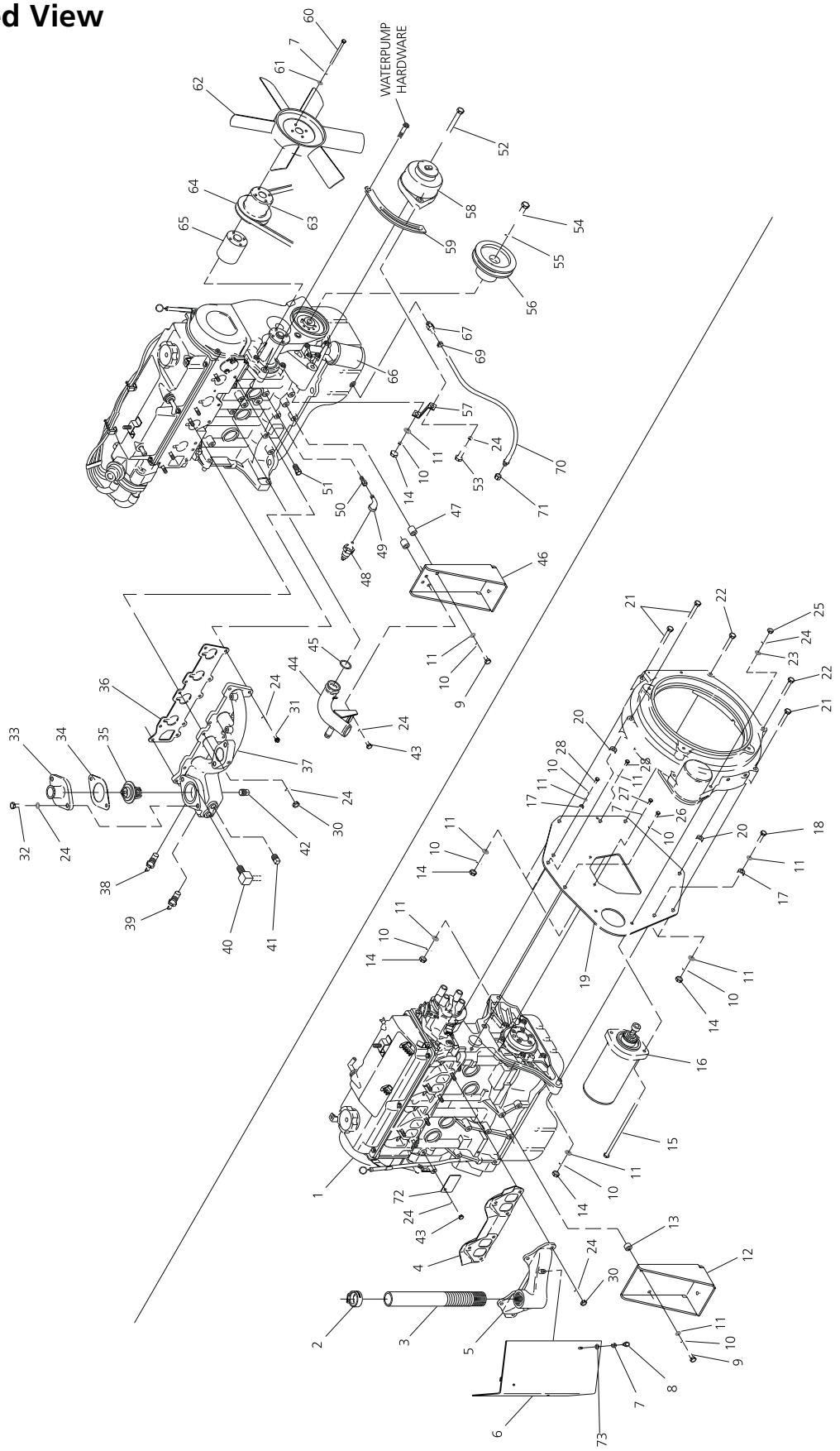
Limit: 0.25 mm



REAR OIL SEAL INSTALLATION

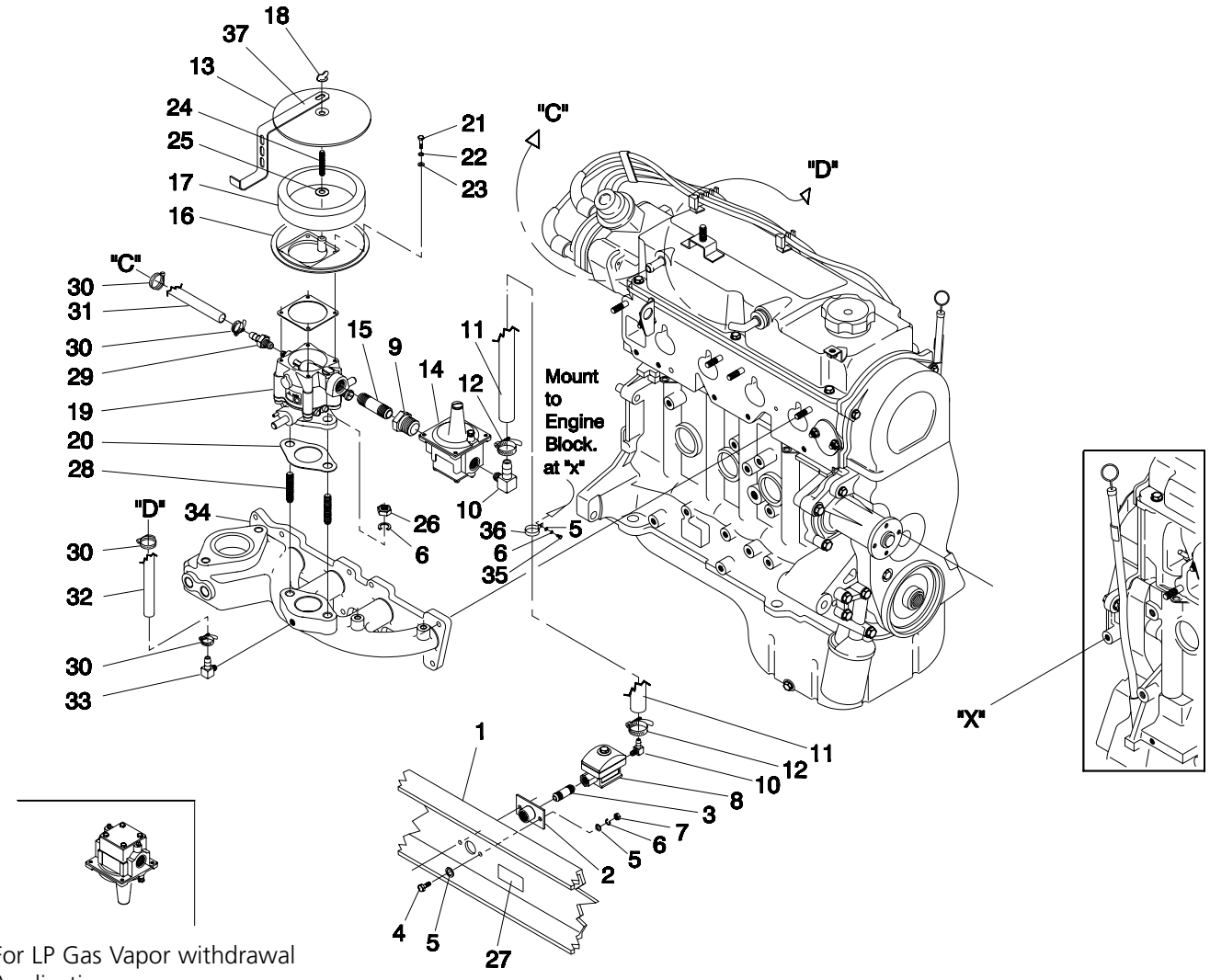
(1) Press-fit the rear oil seal using the special tool shown in the illustration.

Exploded View



ITEM	DESCRIPTION	QTY
1	ENGINE-1.5L	1
2	CLAMP-HOSE-#28	1
3	PIPE-FLEX EXHAUST	1
4	GASKET-EXHAUST MANIFOLD	1
5	MANIFOLD-EXHAUST	1
6	SHIELD-HEAT	1
7	WASHER-LOCK-1/4"	8
8	HHCS-1/4"-20 X 1/2" LG	2
9	HHCS-M10-1.25 X 25 LG	4
10	WASHER-LOCK, M10	14
11	WASHER-FLAT, M10	16
12	LEG-LEFT ENGINE SUPPORT	1
13	SPACER	1
14	HEX NUT-M10-1.50	4
15	SHCS-5/16"-18 X 3" LG	2
16	STARTER-12V	1
17	SPACER-ENGINE PLATE	2
18	HHCS-M10-1.50 X 60 LG	1
19	ENGINE PLATE	1
20	DOWEL SLEEVE-BLOWER HOUSING	2
21	HHCS-M10-1.50 X 70 LG	3
22	HHCS-M10-1.50 X 90 LG	2
23	WASHER-FLAT-5/16"-M8	2
24	WASHER-LOCK-5/16"-M8	23
25	HEX NUT-5/16"-18	2
26	HHCS-M10-1.25 X 20 LG	1
27	HHCS-M6-1.0 X 16 LG	2
28	HHCS-M10-1.25 X 45 LG	2
29	HEX NUT-M10-1.25	1
30	HEX NUT-M8-1.25	10
31	SHCS-M8-1.25 X 25 LG	5
32	HHCS-5/16"-18 X 1" LG	2
33	ADAPTER-THERMOSTAT	1
34	GASKET, WATER OUTLET	1
35	THERMOSTAT	1
36	GASKET-INTAKE MANIFOLD	1
37	MANIFOLD-INTAKE	1
38	SENSOR, WATER LEVEL	1
39	SWITCH-WATER TEMPERATURE	1
40	FITTING-, HOSE BARB, 3/8"P X 5/8"H	1
41	FITTING-PIPE PLUG-3/8" NPT	1
42	FITTING-PIPE PLUG-1/8" NPT	1
43	HHCS-M8-1.25 X 20 LG	6
44	TUBE-WATER INLET	1
45	SEAL, O-RING	1
46	LEG-RIGHT ENGINE SUPPORT	1
47	SPACER	2
48	SWITCH-OIL PRESSURE	1
49	FITTING-STREET ELBOW-1/8" NPT	1
50	ADAPTER-OIL PRESSURE SWITCH	1
51	FITTING-PIPE PLUG-1/4" NPT	1
52	HHCS-M10-1.5 X 110 LG	1
53	HHCS-M8-1.25 X 35 LG	1
54	HHCS-M12-1.25 X 55 LG	1
55	WASHER-LOCK-M12	1
56	PULLEY-CRANKSHAFT (1800 RPM)	1
	PULLEY-CRANKSHAFT (3600 RPM)	1
57	BRACKET, ALTERNATOR SUPPORT	1
58	DC ALTERNATOR-12V	1
59	BRACKET-ALTERNATOR ADJUSTMENT	1
60	HHCS-M6-1.0 X 70 LG	4
61	WASHER-FLAT-1/4"-M6	4
62	FAN-RADIATOR	1
63	PULLEY-FAN	1
64	V-BELT (1800 RPM)	1
	V-BELT (3600 RPM)	1
65	SPACER-FAN PULLEY	1
66	FILTER-OIL	1
67	ADAPTER-OIL DRAIN	1
69	CLAMP-HOSE	1
70	HOSE ASM.-OIL DRAIN	1
71	CAP-OIL DRAIN HOSE	1

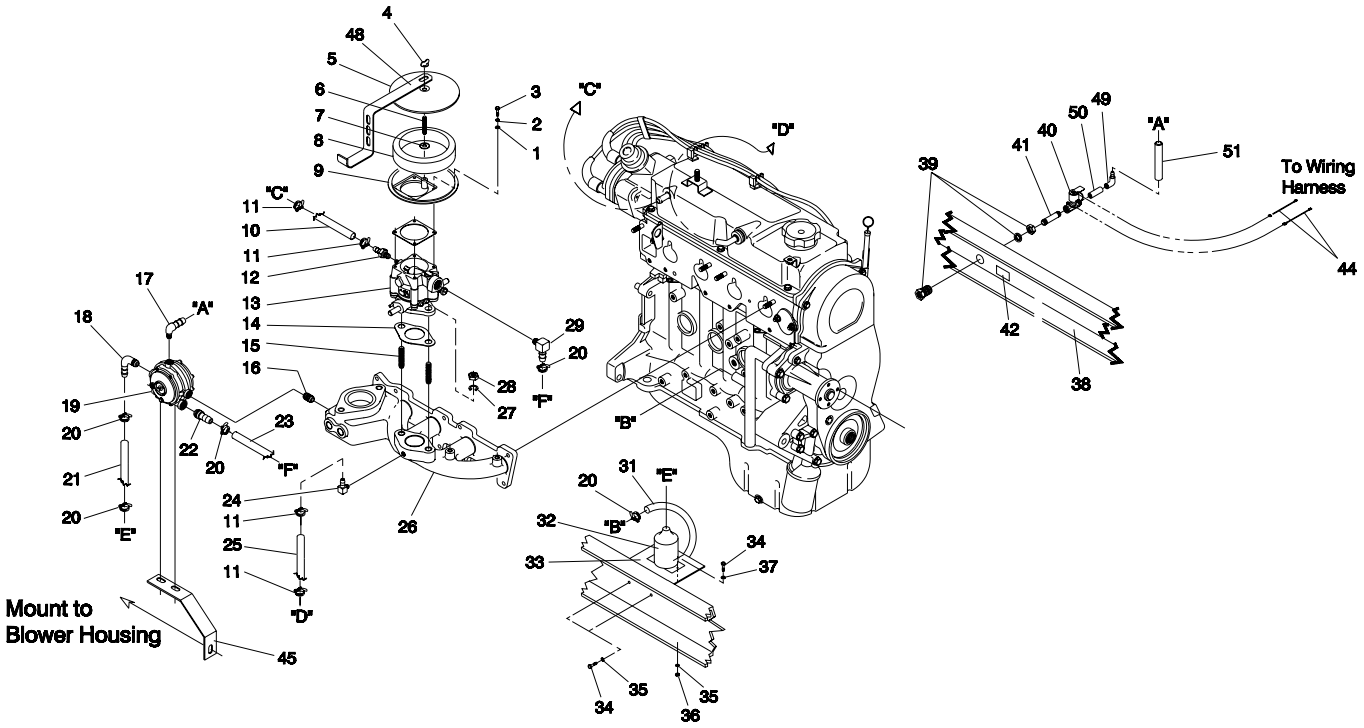
Exploded View



For LP Gas Vapor withdrawal Application

ITEM	DESCRIPTION	QTY
1	BASE, MOUNTING	1
2	FLANGE, FUEL INLET	1
3	NIPPLE, 3/4" NPT	1
4	CAPSCREW, HEX HD.-M8-1.25 X 20MM	2
5	WASHER, FLAT-M8	5
6	WASHER, LOCK-M8	5
7	NUT, HEX M8-1.25	2
8	SOLENOID, VALVE	1
9	BUSHING, RED 3/4" X 3/8"	1
10	FITTING, BARBED 90 DEG. 3/4" NPT X 5/8"	2
11	HOSE, 5/8" I.D. X 31" LONG	31"
12	CLAMP, HOSE #10	2
13	COVER, AIR CLEANER	1
14	VALVE, PRESSURE (NATURAL GAS)	1
	VALVE, PRESSURE (LP VAPOR)	1
15	NIPPLE, PIPE 3/8" NPT X 4" LONG	1
16	ADAPTOR, AIR CLEANER	1
17	CLEANER, AIR	1
18	WING NUT, 1/4-20	1
19	CARBURETOR	1
20	GASKET-CARBURETOR	1
21	RD. HD. MACH. SCREW-#10-24 X 1/2"	4
22	WASHER-LOCK #10	4
23	WASHER-FLAT #10	4
24	STUD 1/4-20 X 3" LONG	1
25	1/4-20 HEX NUT	1
26	5/16-18 HEX NUT	2
27	DECAL, FUEL INLET	1
28	STUD 5/16-18 X 1-1/2" LONG	2
29	BARB FITTING 5/16H X 1/8P	1
30	HOSE CLAMP 1/4"	4
31	HOSE 9/32" I.D.	6-1/2"
32	HOSE 9/32" I.D.	11"
33	BARB FITTING 90 DEG. 5/16H X 1/8P	1
34	MANIFOLD-INTAKE	1
35	HHCS-M8-1.25 X 16 LONG	1
36	CLAMP-VINYL 1"	1
37	BRACKET-RADIATOR HOSE	1

Exploded View



ITEM	DESCRIPTION	QTY
1	WASHER, FLAT #10	4
2	WASHER, LOCK #10	4
3	RD. HD. MACH. SCREW-#10-24 X 1/2	4
4	WING NUT, 1/4-20	1
5	COVER, AIR CLEANER	1
6	STUD 1/4-20 X 3" LONG	1
7	1/4-20 HEX NUT	1
8	CLEANER, AIR	1
9	ADAPTOR, AIR CLEANER	1
10	HOSE 9/32” I.D.	6-1/2”
11	HOSE CLAMP, 1/4	4
12	BARB FITTING 5/16H X 1/8P	1
13	CARBURETOR	1
14	GASKET, CARBURETOR	1
15	STUD, 5/16-18 X 1-1/2" LONG	2
16	CLOSE NIPPLE 3/8" NPT	1
17	ELBOW, BRASS-ST. 1/4" NPT	1
18	ELBOW, 3/8" NPT X 5/8	1
19	VAPORIZER, LP GAS	1
20	HOSE CLAMP, #10	5
21	HOSE 5/8 I.D. SAE-20R3-32"	1
22	BARBED ST. 1/2 X 5/8	1
23	HOSE 5/8 I.D. X 18"	1
24	BARB FITTING 90 DEG. 5/16H X 1/8P	1
25	HOSE 9/32” I.D.	11"
26	MANIFOLD, INTAKE	1
27	WASHER, LOCK-M8	6
28	5/16-18 HEX NUT	2
29	FITTING, BARBED 90 DEG. 3/4 NPT X 5/8"	2
31	HOSE 5/8 I.D. SAE-20R3-18"	1
32	KIM, HEATER 500W 1020	1
33	BRACKET, HEATER	1
34	HHCS-M6-1.00 X 16 LONG	4
35	WASHER-LOCK, 1/4 M6	4
36	NUT, HEX M6-1.0	2
37	WASHER, FLAT 1/4”-M6	2
38	MOUNTING BASE	1
39	BULKHEAD ADAPTOR	1
40	FUEL SOLENOID LP LIQUID	1
41	NIPPLE, 1/4" NPT	1
42	DECAL, FUEL INLET	1
44	WIRE, FUEL SOLENOID	2
45	BRACKET, VAPORIZER	1
48	BRACKET-RADIATOR HOSE	1
49	FITTING 90DEG. 1/4” NPT X 7/16”	1
50	COUPLING PIPE 1/4” NPT	1
51	FUEL LINE LPG 24.5” LONG	1

GENERAC®
POWER SYSTEMS, INC.

Manual Part No. C1947